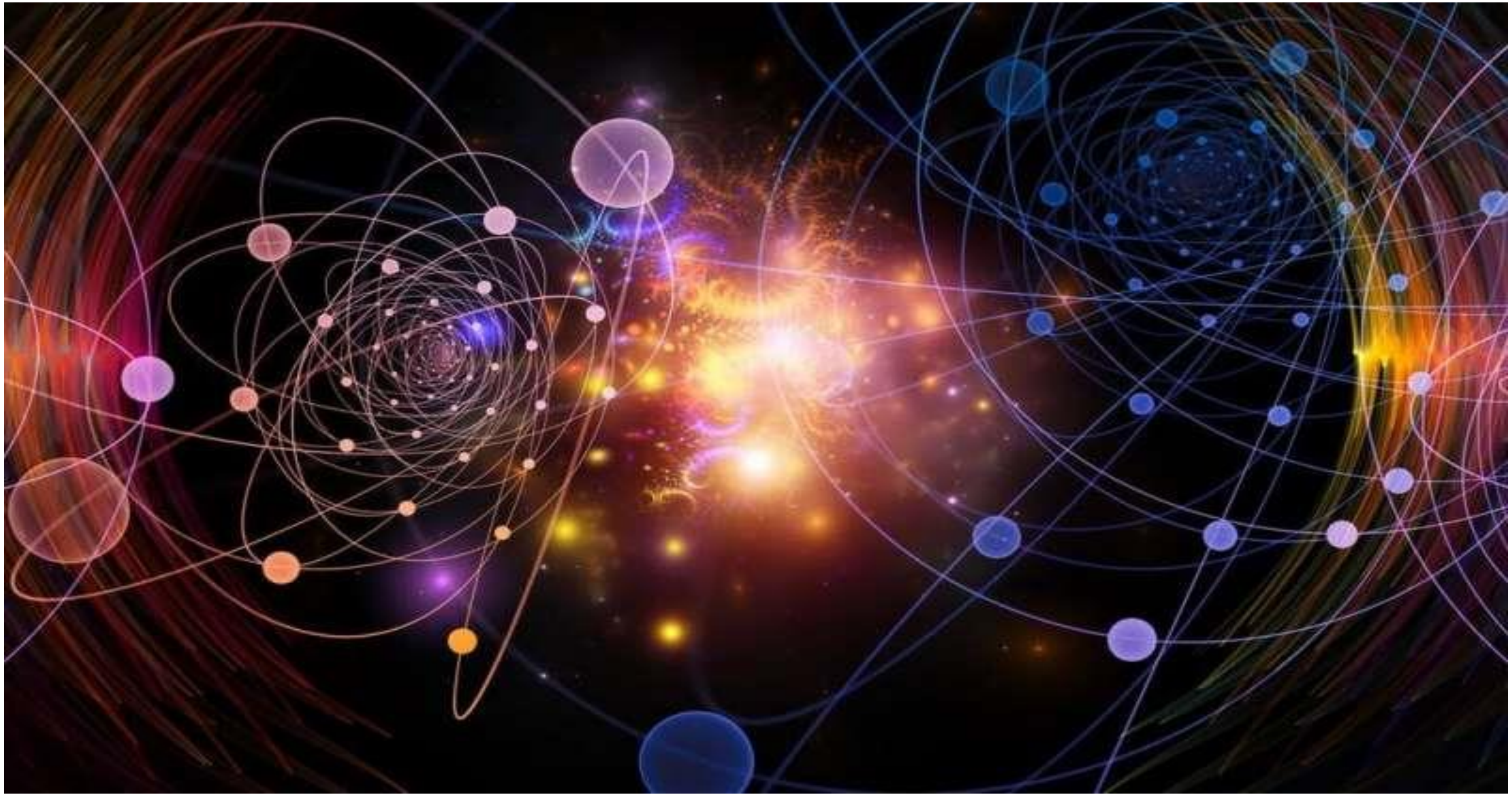
MATTER AROUND US



Things around us………

MATTER AROUND US

- Introduction
- Kinetic molecular theory of matter
- States of matter
- Interconversion of states of matter
- Evaporation
- Plasma
- Bose-Einstein Condensate

INTRODUCTION

Early Indian philosophers classified matter in the form of five basic elements
”Panch Tatva”- air, earth, fire, sky and water.

Ancient Greek philosophers also classified matter in similar manner.

In our surroundings, we see a large variety of things with different shapes, sizes and textures. The air we breathe, the food we eat, stones, clouds, stars, plants and animals, even a small drop of water or a particle of sand, everything is matter.

MATTER

Anything which occupies space(or have volume) and has mass is called matter.

Some examples of matter are **water, air, metals, plants, animals,** etc.

NOTE

The perception of joy, love, hate, thought, cold, hot, pain, heat, light, sound, electricity or even our shadow are not considered as matter.

Properties of Matter

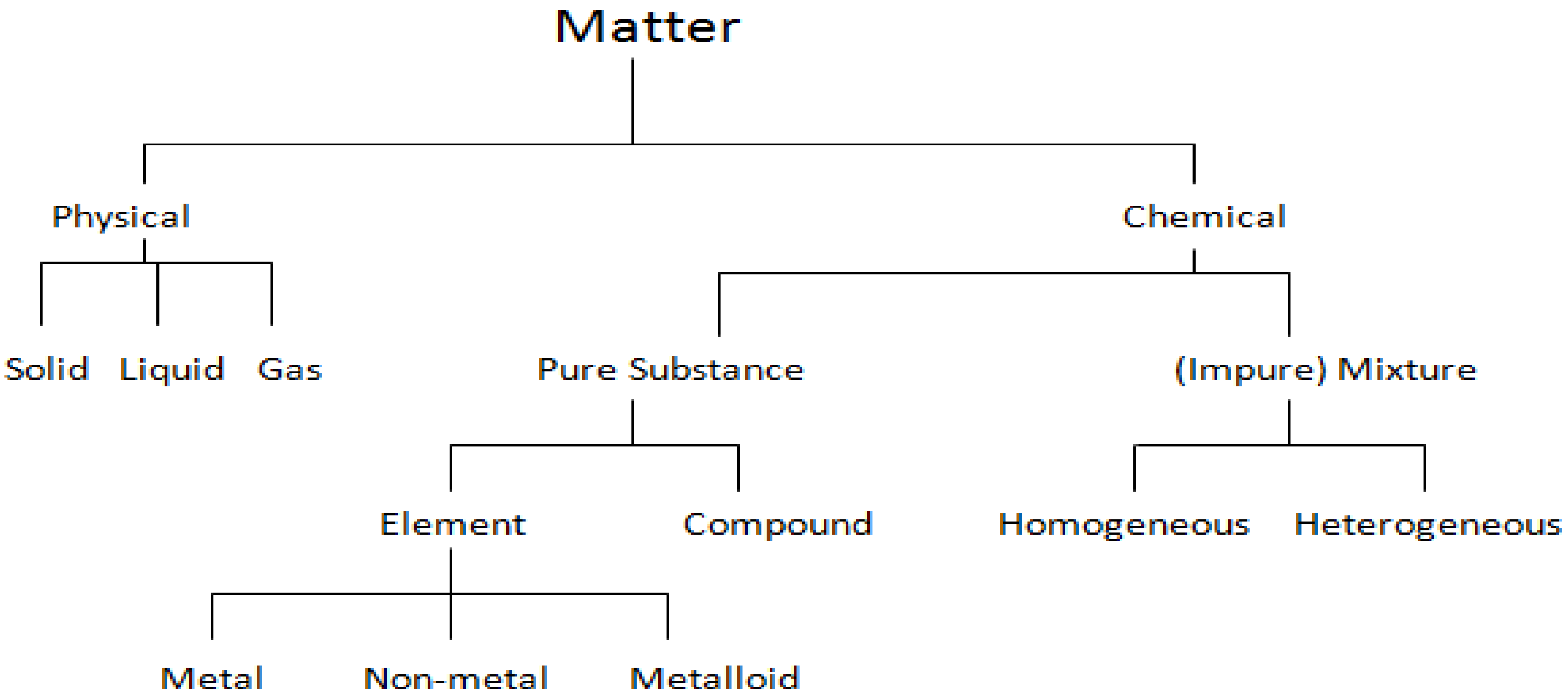
1. **The matter has mass.**
2. **The matter occupies space.**
3. **The matter has inertia.**
4. **The matter is effected by the gravity.**
5. **The matter cannot be destroyed.**

The matter can be classified into different categories depending upon its **physical** or **chemical nature.**

(1) Physical classification: On the basis of physical properties, matter has been classified as solids, liquids and gases.

(2) Chemical classification: On the basis of chemical properties. matter has been classified as elements, compounds and mixtures.

CLASSIFICATION OF MATTER


Matter

Physical

Solid

Liquid

Gas

Chemical

Pure Substance

Element

Metal

Non-metal

Metalloid

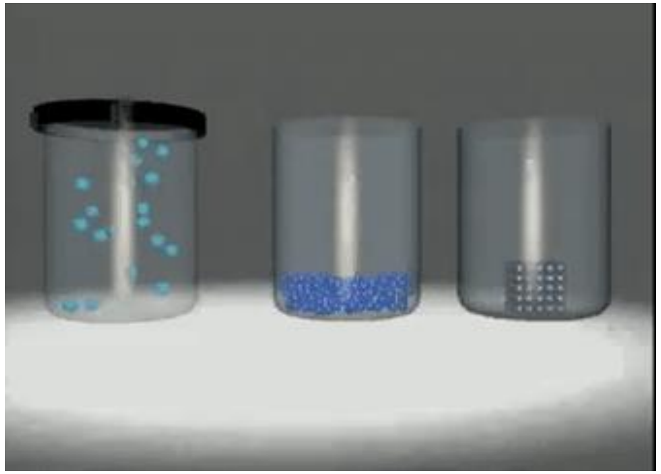
Compound

(Impure) Mixture

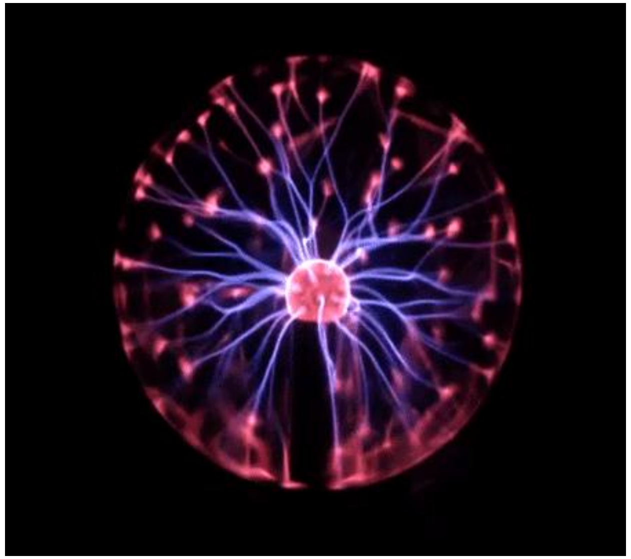
Homogeneous

Heterogeneous

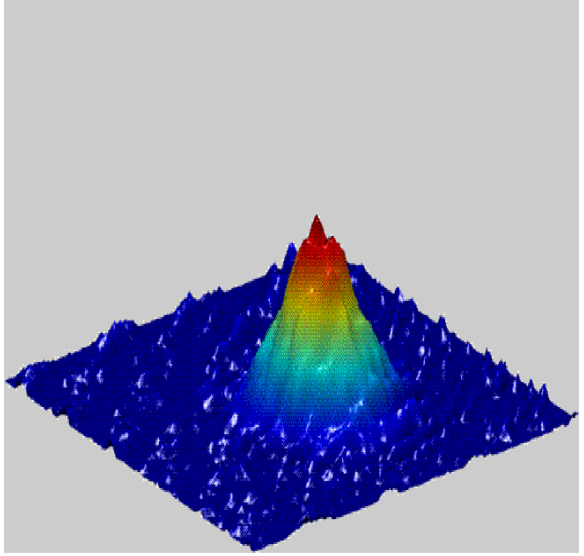
Physical states of matter



Solid, Liquid and Gas



Plasma



Bose-Einstein Condensate

PHYSICAL NATURE OF MATTER

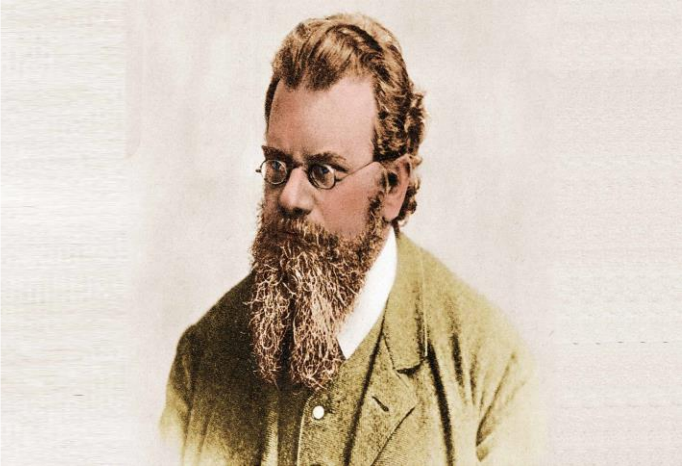
From a long time there were two views about the physical nature of matter.

(i) Continuous nature: like a block of wood or sheet of glass.

(ii) Particulate nature: that matter is made up of particles like sand.

What do you think, nature of matter will be

continuous nature
or
particulate nature????



Let us understand with an ACTIVITY.

Activity

Aim

To show the particle nature of matter.

Materials required

Beaker(100 mL), water, glass rod, sugar.

Method

(a)Take about 50 mL water in 100 mL beaker.
(b) Mark the level of water.
(c)Add some sugar to the beaker.
(d)Stir with the help of a glass rod.

Observation and Conclusion

(a) The sugar settled at the base of the beaker, as it is a continuous form of matter.

(b) On stirring, the sugar disappeared i.e. it dissolved in water. This dissolving or disappearance of sugar in water suggests that sugar is not a continuous state of matter. Instead, it is made of extremely small particles. The water breaks down the sugar into small particles that they are no longer visible to the eye.

(c) The level of water in the beaker does not rise or fall. This suggests that particles of sugar got dispersed in water. This also suggests that there must be some hollow spaces in water. This implies that water by itself is not continuous, but is made of extremely small particles, which are not visible to the eye.

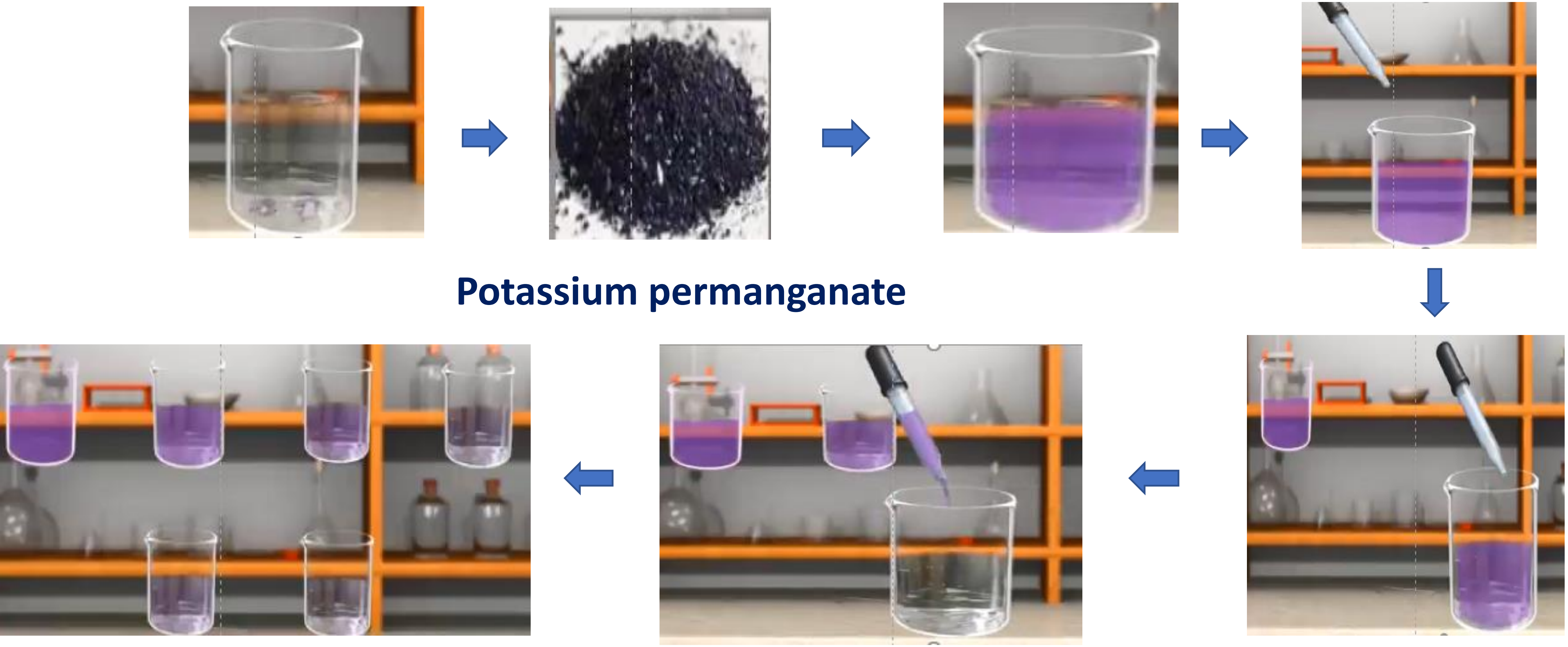
(d) The extremely small particles of sugar positioned themselves in the small spaces between the particles of water. This also accounts for the fact that level of water does not rise, because the particles of sugar do not displace it but occupy small spaces in between the particles of water.

CHARACTERISTICS OF PARTICLES OF MATTER

PARTICLES OF MATTER

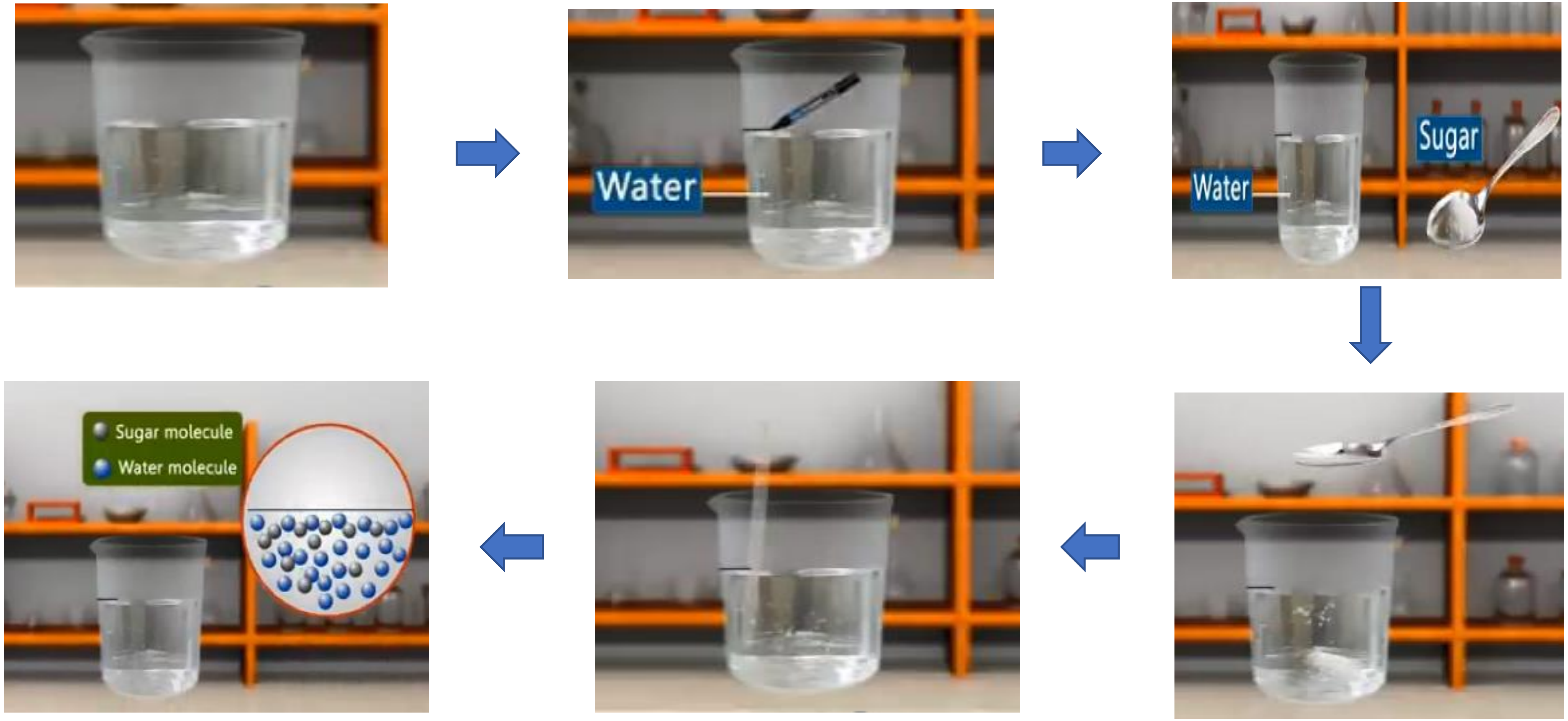
1. Are extremely small in size
2. Have spaces between them
3. Attract each other
4. Are continuously in motion

Particles of matter are extremely small in size



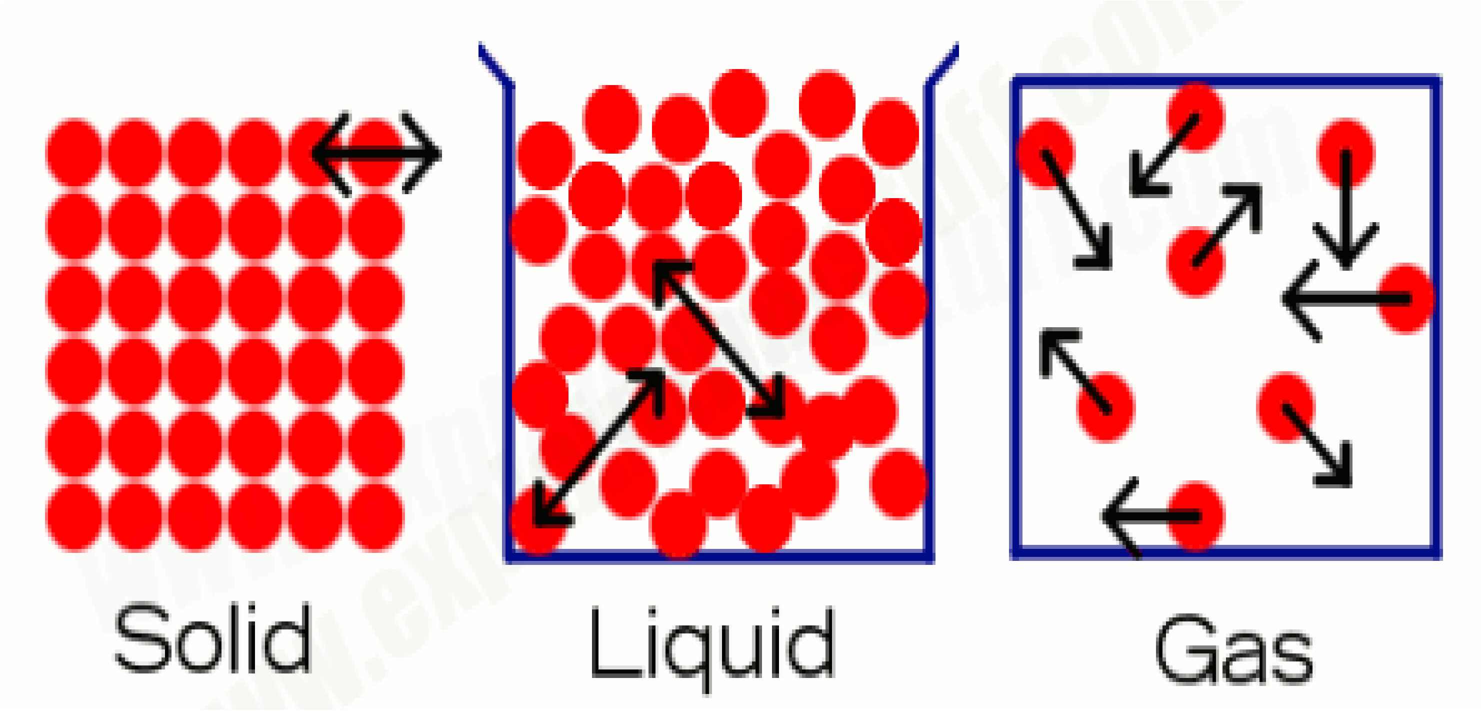
Potassium permanganate

Particles of matter have space between them



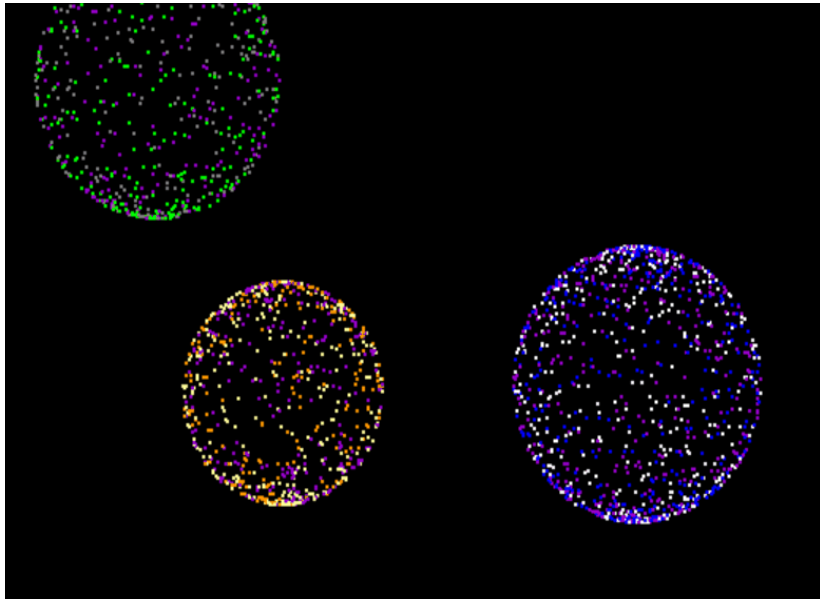
The space between the particles

- Minimum in solids.
- More in liquids.
- Maximum in gases.

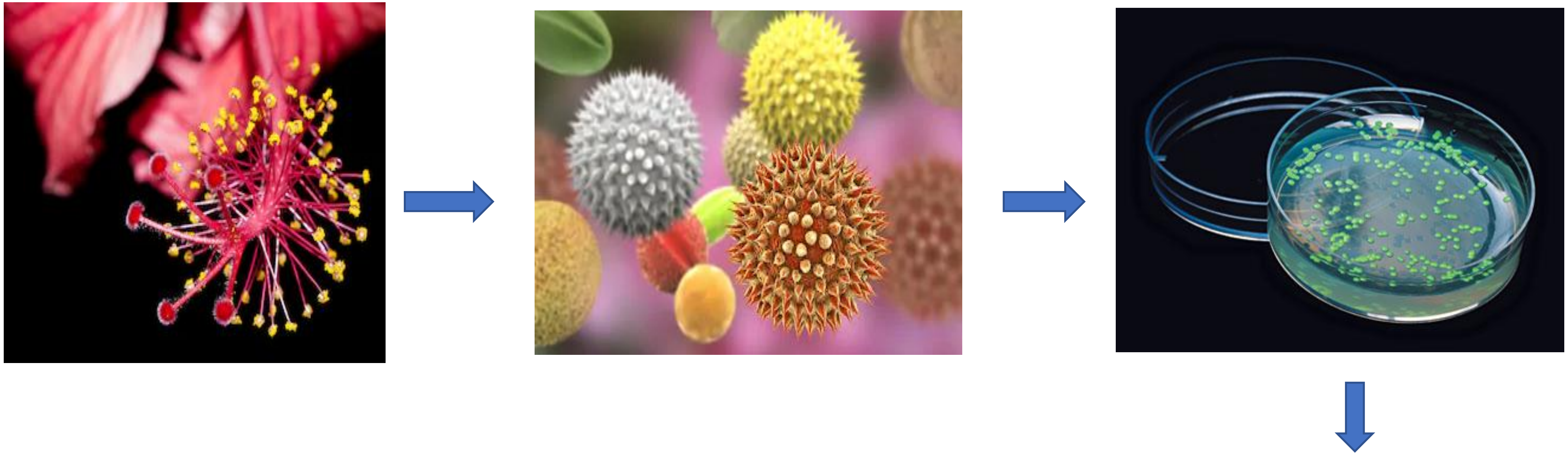


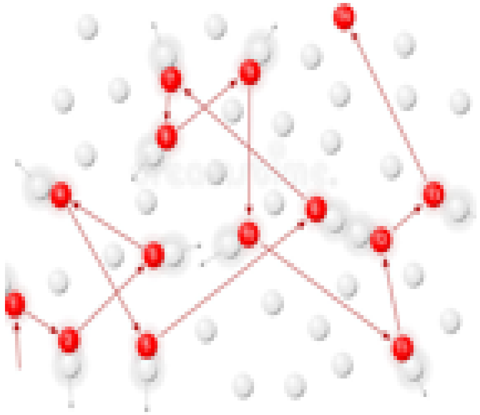
Collision of particles

- The particles, especially in gaseous or liquid state, are moving in a **Helter- Skelter** direction.
- They collide with one another but these collisions are elastic.
- The total energy of the colliding particles remain the same.
- The movement is caused by the force of attraction between the molecules of a given substance. This force is known as intermolecular force.
- The magnitude of the force depends upon the state of the substance as well as upon the magnitude of the intermolecular spaces.



Dust particles are seen doing random motion in air because of their collisions with randomly moving tiny particles of air around them.





The tiny particles of water do collision with pollen grains.

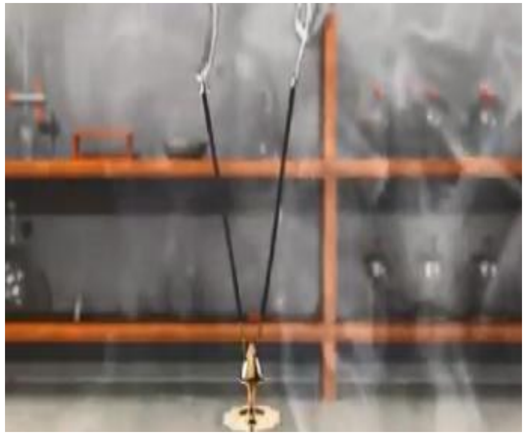
Due to these collisions, pollen grains move slightly.

It proves that:

1. Matter is made up of tiny particles.
2. Particles do **Brownian motion**.

Particles of matter are continuously moving

Incandescent stick

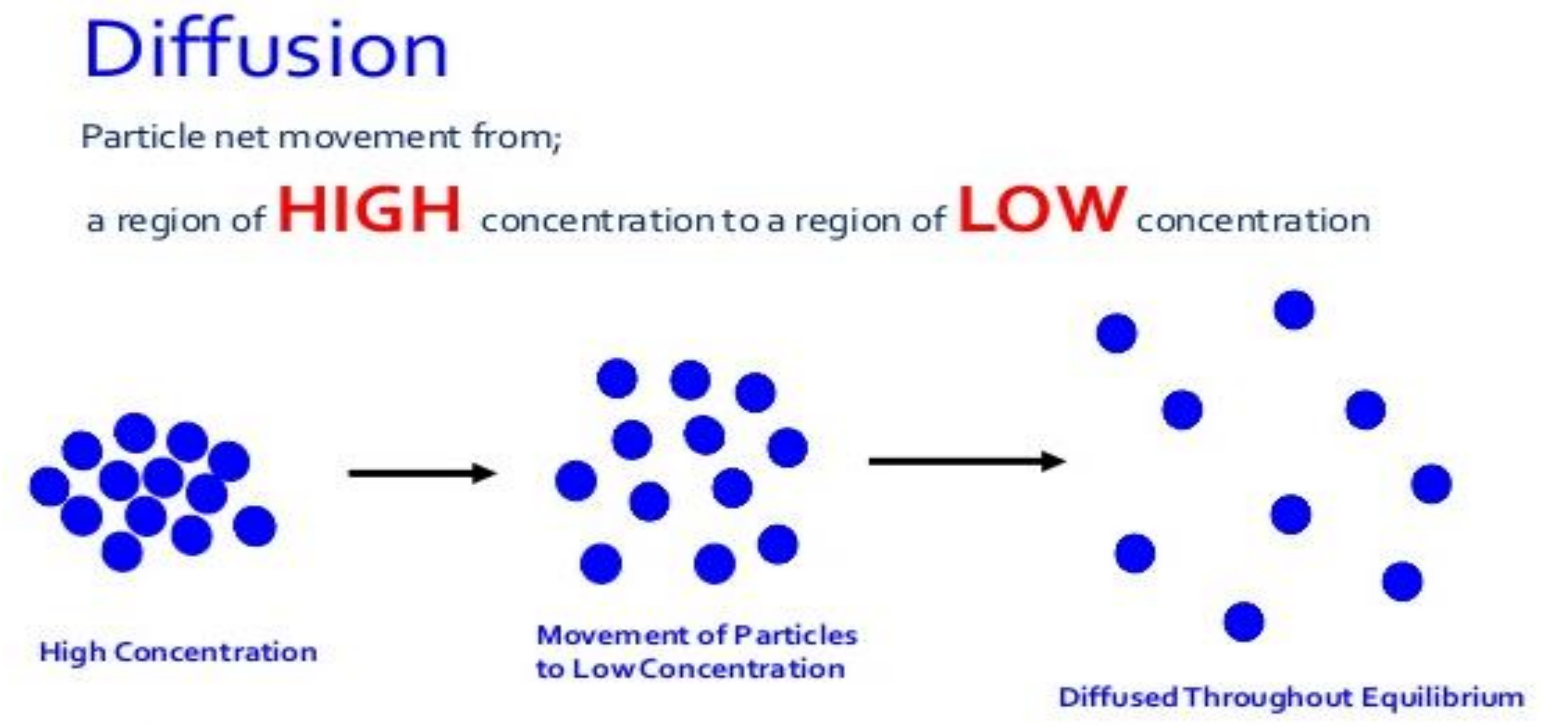


Fragrance of Perfume

Smell of hot food

Diffusion

The spontaneous intermixing of particles of two or more different substances is called diffusion.



Diffusion

Particle net movement from;

a region of HIGH concentration to a region of LOW concentration

High Concentration
Movement of Particles to Low Concentration
Diffused Throughout Equilibrium

Particles posses Kinetic energy.

Movement is

- Minimum in solids.
- More in liquids.
- Maximum in gases.

As the **temperature** rise particles moves faster because **Kinetic energy** increases.

Diffusion of ink
in cold water

Diffusion of ink
in hot water

CONCEPTUAL CHALLENGE:

1. Why liquid diffuse slowly as compared to gases?

2. What would have happened to the gas if the molecular collision were not elastic?

3. Salt get dissolved in water easily even it is not externally stirred. Why?

1. Why liquid diffuse slowly as compared to gases?

Explanation:

In liquids, the molecules are less free than in a gas, i.e., the intermolecular forces are greater than in a gas.

Atoms, molecules or ions are in constant motion as given in kinetic molecular theory of matter.

This motion may be:

(i) **Translatory:** The motion of particle in a particular direction.

(ii) **Rotational:** Motion around the axis.

(iii) **Vibratory:** To and fro motion of particles about the mean position.

2. What would have happened to the gas if the molecular collision were not elastic?

Explanation:

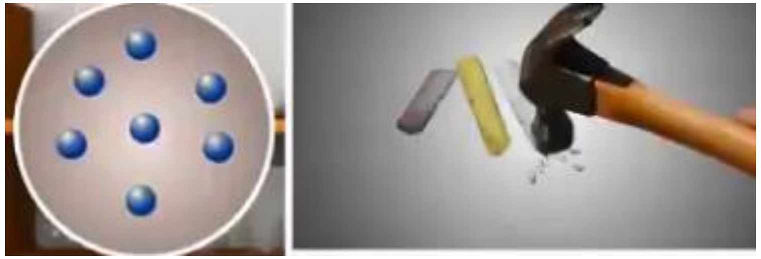
On every collision, there would have been loss of energy. As a result, the molecules would have slowed down and ultimately settle down in the vessel. Moreover, the presence would have gradually reduced to zero.

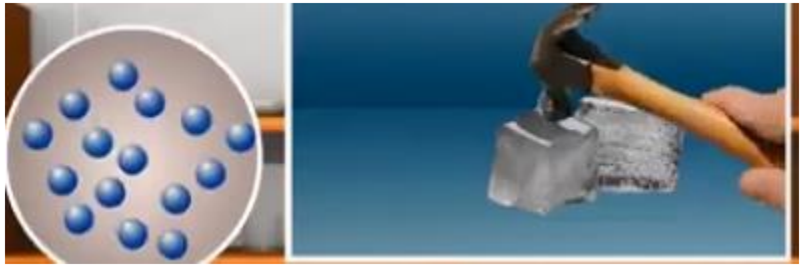
3. Salt get dissolved in water easily even it is not externally stirred. Why?

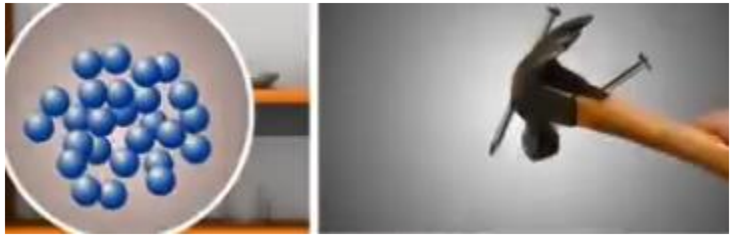
Explanation:

Salt molecules and water molecules having their own kinetic energy when comes in contact starts mixing up on its own. It means the salt particles move from top to bottom in the water.

Particles of matter attract each other







Example

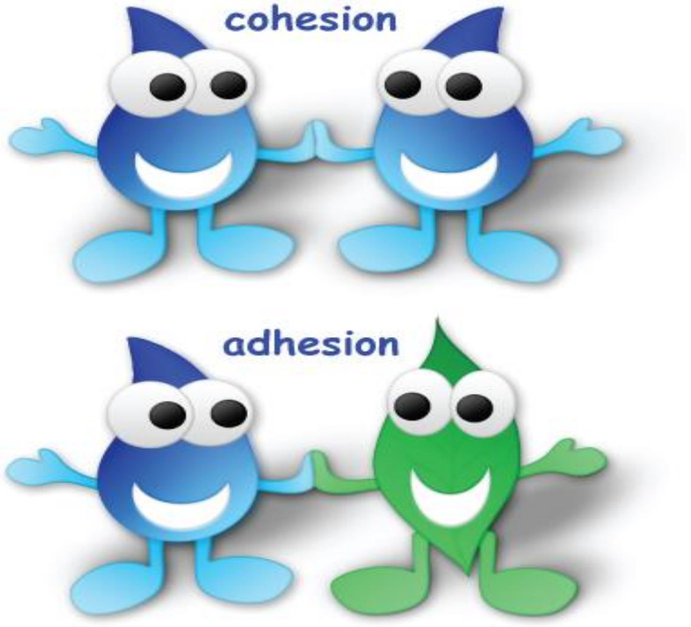
Types of forces

1. Cohesive force

The force of attraction between the particles of the same substance is known as cohesive force.

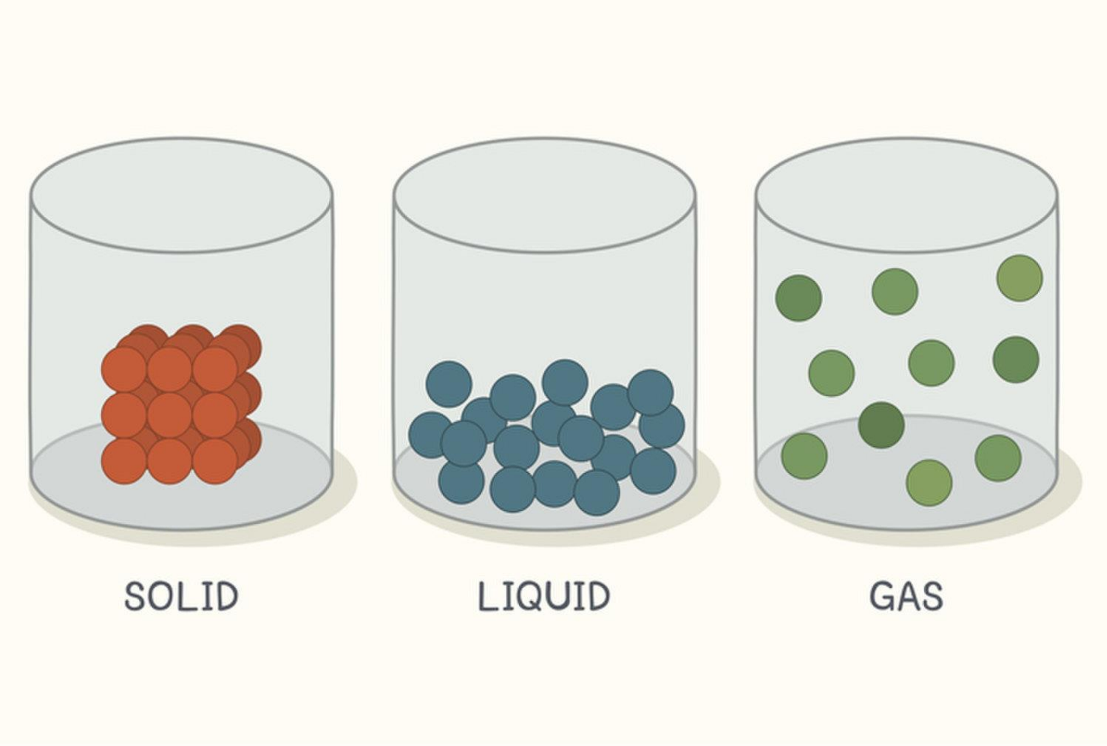
2. Adhesive force

The force of attraction between the particles of the different substance is known as adhesive force.

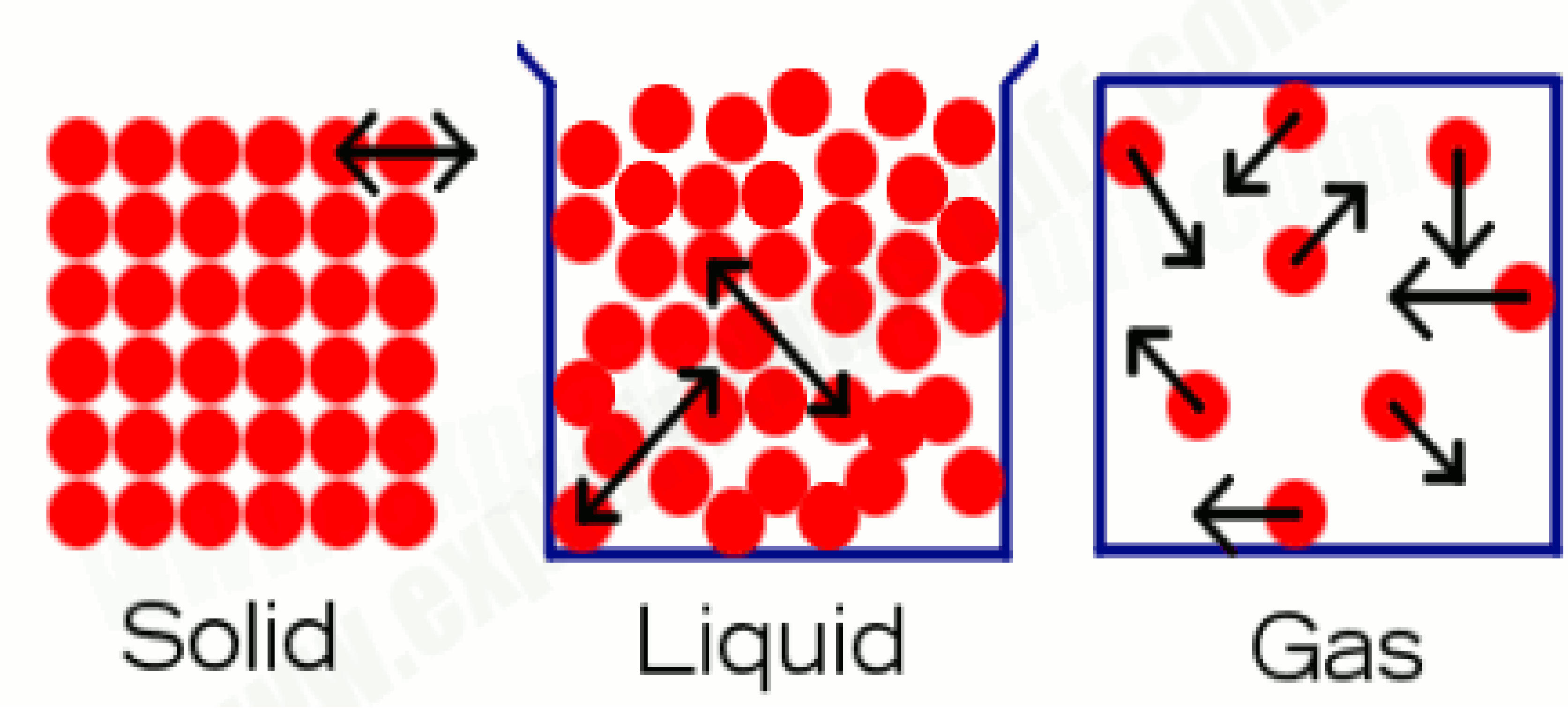


The force of attraction

- Maximum in solids
- Intermediate in liquids
- Negligible in gases



STATES OF MATTER



- **The three states of matter exist and differ from one another on account of:**

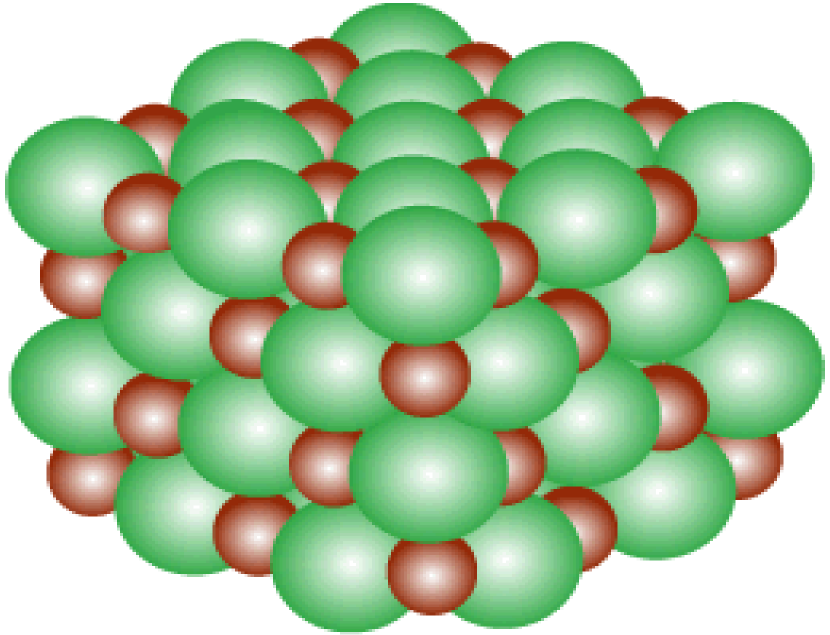
(I) The type of packing of their constituent particles.

(II) Energy associated with these particles.

(III) Inter molecular forces between them.

THE SOLID STATE

Solid are known for their hardness and rigid nature



Solid state

Characteristics of solid state

(1)Solids have fixed shapes: Solids generally have fixed shapes. They do not change their shapes even when put in different containers, For example, blue crystals of copper sulphate have needle like shape which they retain whether kept in a beaker or in a china dish or placed in the palm of our hand.

(2) Some solids can change their shape under force but regain the same when the applied force is removed. For example, a sponge on pressing changes its shape, but regains it after force is removed.

(3) Solids keep their volume which mean that they have fixed volume. For example, a sponge on pressing changes its shape, but regains it after force is removed. Volume is the space occupied by a substance. The solids have fixed volume. Actually in the solid state, the constituents are very closely packed in space and interparticle forces are strong. As a result, the solids keep their volume.

(4) Solids can be hardly compressed on applying pressure. It is very difficult to compress a solid on applying pressure. For example, we cannot compress a piece of stone by applying pressure with our hands. Actually, the constituent particles are so closely packed in a solid that they either do not come closer or do so only slightly when a high pressure is applied. However, there are some exceptions.

(5) Solids have negligible kinetic energy of the particles. The kinetic energy is linked with movement of the particles from one place to the other. Since the constituents in the solid state are very closely they have negligible kinetic energy. That is why solids do not flow.

(6) Solids do not have the property of diffusion. Due to the absence of kinetic energy in the particles of a solid, there is hardly any diffusion. For example, let us keep pieces of metals like copper and silver side by side. They may touch each other but will not mix.

For example, **Table, chair, common salt, silver, ice, diamond, stone, sugar, etc.**

Kinetic model of solids

a)The molecules are closely packed. In other words the intermolecular space, which can exists between the molecules, is negligible.

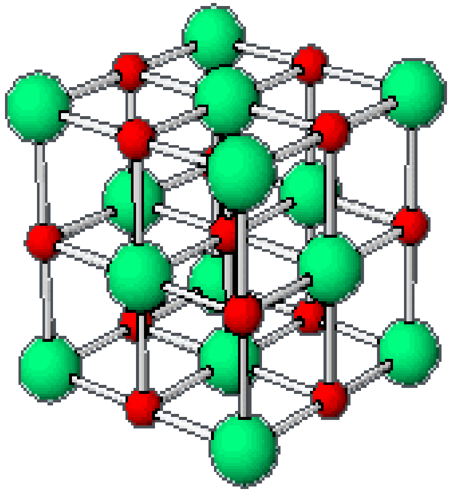
b)The molecule have fixed position. That is, there is no movement.

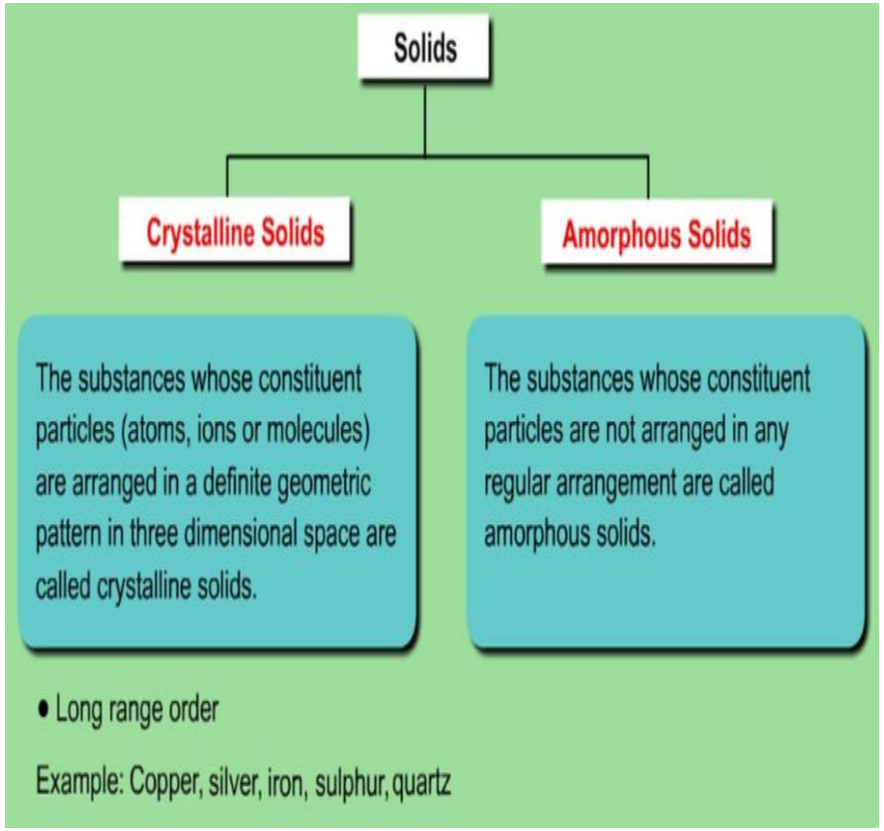
c)The molecules are arranged in a definite manner.

d)There is a strong force of attraction between them.

Types of Solids

Solids are classified into two groups based on the arrangement of constituent particles.





Solids

Crystalline Solids

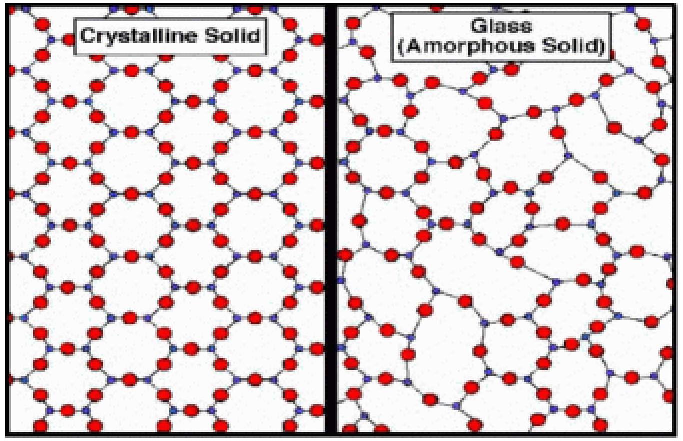
The substances whose constituent particles (atoms, ions or molecules) are arranged in a definite geometric pattern in three dimensional space are called crystalline solids.

Amorphous Solids

The substances whose constituent particles are not arranged in any regular arrangement are called amorphous solids.

- Long range order

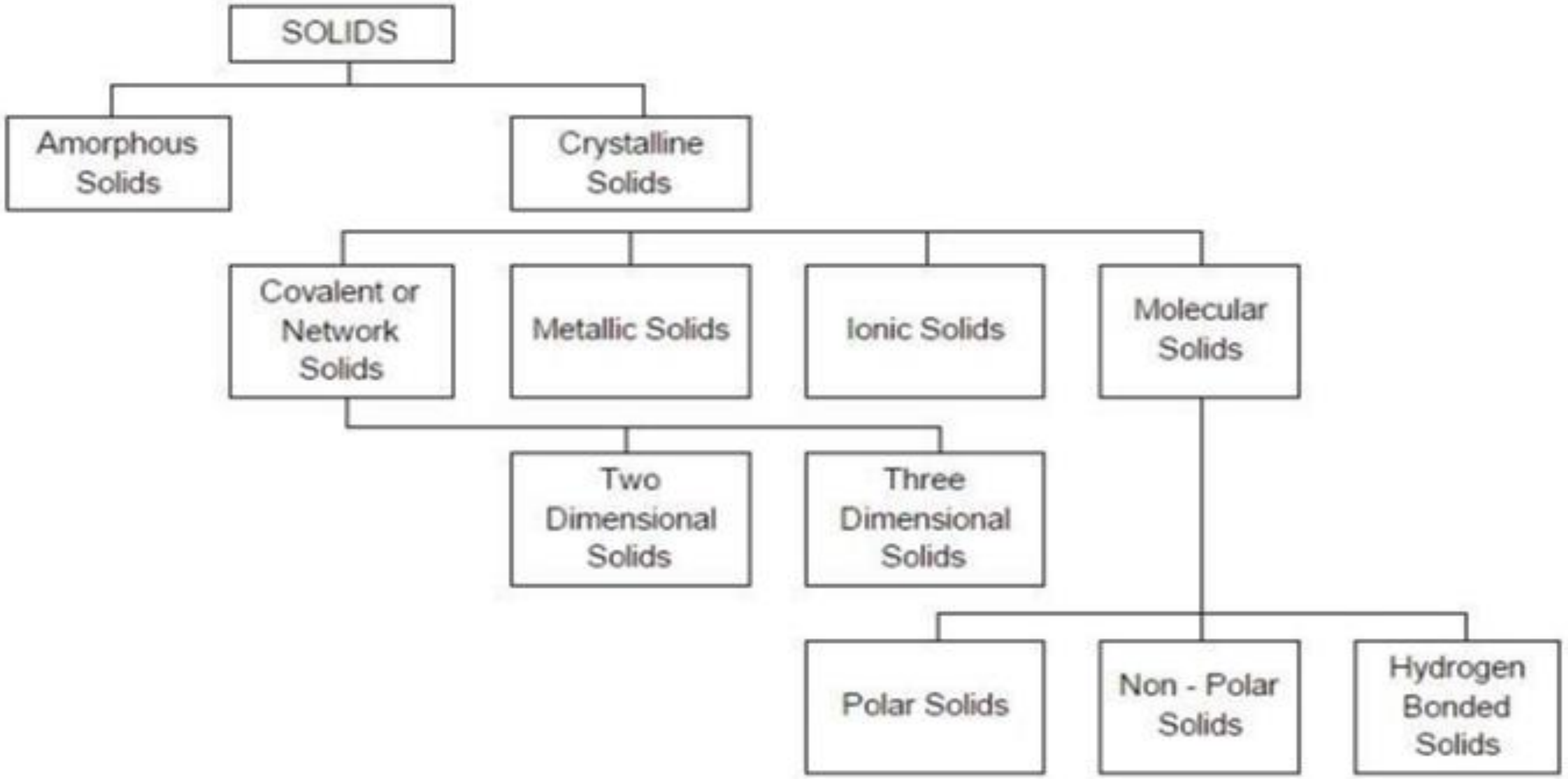
Example: Copper, silver, iron, sulphur, quartz



Difference between crystalline and amorphous solids

	Properties	Crystalline solids	Amorphous solids
1	Crystal geometry	These have a definite crystal shape due to orderly arrangement of atoms, molecules or ions in three dimensional network.	These do not have a definite geometrical shape due to haphazard order of constituent particles.
2	Melting point	These show sharp melting point.	These do not show sharp melting point.
3	Physical state	These are hard and rigid solids.	These are comparatively soft and not very rigid.
4	Symmetry	Crystalline solids have (a) Plane of symmetry (b) Centre of symmetry (c) Axis of symmetry	Amorphous solids do not have any symmetry.
5	Crystal system	Crystalline solids have a definite crystal system e.g., cubic, tetragonal, hexagonal, etc.	These do not have any crystal system i.e. these do not have a regular repeating units.
6	Anisotropic or isotropic nature	Crystalline solids show physical properties different in different directions of the crystal e.g., refractive index and electrical conductivity. So they are termed as anisotropic.	Their physical properties are same in all directions. Thus these are termed as isotropic.
7	Examples	Crystals of NaCl, KBr, ZnS, etc.	Rubber, plastic, glass, etc.

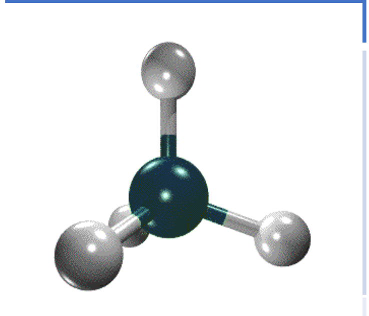
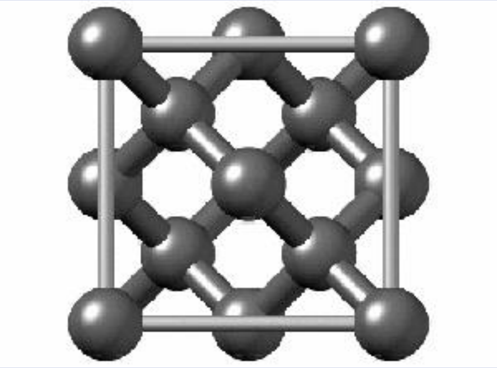
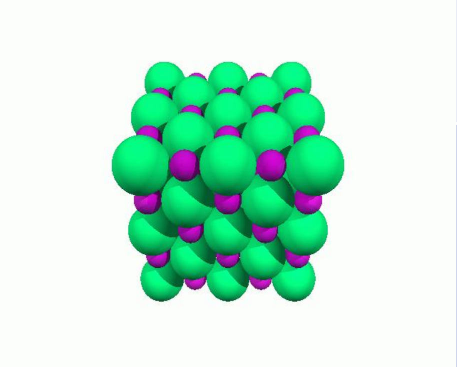
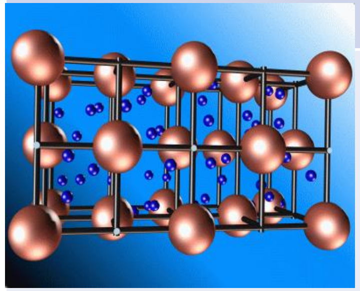
Classification of solids



SOLIDS

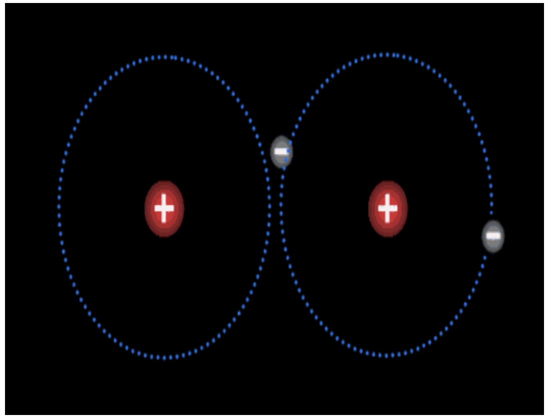
- Amorphous Solids
- Crystalline Solids
  - Covalent or Network Solids
    - Two Dimensional Solids
    - Three Dimensional Solids
  - Metallic Solids
  - Ionic Solids
  - Molecular Solids
    - Polar Solids
    - Non - Polar Solids
    - Hydrogen Bonded Solids

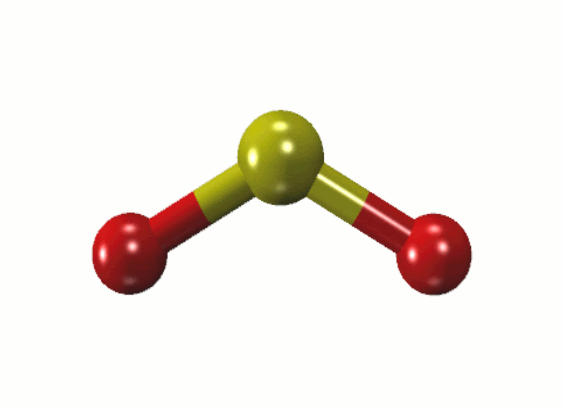
Classification Of Crystalline Solids

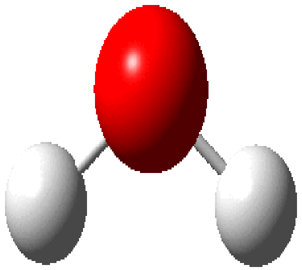
Type of solid	Form of Unit particles	Forces Between Particles	Properties	Examples
	Atoms or molecules	London forces, dipole-dipole forces, hydrogen bonds	Soft, low to moderately high melting point, poor thermal and electrical conductivity	Argon, Methane, Sucrose, Dry ice
Covalent	Atoms		Very hard, very high melting point, often poor thermal and electrical conduction	Diamond, Quartz
Ionic	Positive and negative ions	Electrostatic attractions	Very hard, very high melting point, often poor thermal and electrical conduction	
	Atoms	Metallic bonds	Hard and brittle, high melting point, good thermal and electrical conduction	Cu, Fe, Al, Pt

Molecular Solids

Non - Polar	Polar	Hydrogen-Bonded
Soft	Soft	Hard
Insulator of electricity	Insulator of electricity	Insulator of electricity
Very low melting point	Low melting point	Low melting point
Dispersion or London forces	Dipole-Dipole interaction	Hydrogen bonding
Argon, Helium, Hydrogen, Carbon di oxide	Hydrogen Chloride, Sulphur di oxide	Water(Ice)







CONCEPTUAL CHALLENGE:

1. Classify the following substances into ionic, covalent, molecular or metallic.

MgO, SO_2, I_2, H_2O(ice), SiO_2(quartz), brass

Solution

MgO= Ionic, SO_2= Polar molecule, I_2= Non-polar, H_2O= Hydrogen bonded molecular, SiO_2= Covalent molecule, Brass= Metallic

CONCEPTUAL CHALLENGE:

2. Why a wooden block should be called a solid?

Solution

A wooden block has a fixed shape and is rigid and follows all properties of a solid. Hence, it should be called a solid.

CONCEPTUAL CHALLENGE:

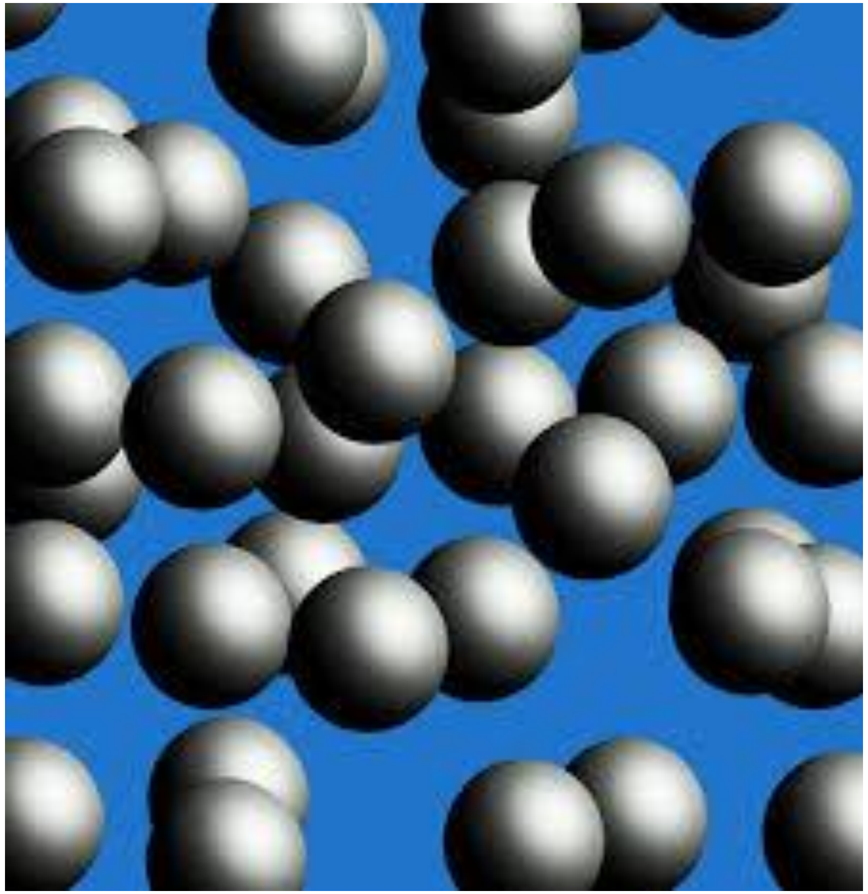
3. A rubber band undergoes a change in shape on stretching, still we call it a solid. Why?

Solution

A rubber band is called a solid because although it undergoes a change in shape on stretching yet it regains the same shape when the force is removed.

THE LIQUID STATE

The liquids are less rigid than the solids and
the molecular motion is also comparatively more.
Both these characteristics in the liquid state are
because of the presence of weaker interparticle forces.



Characteristics of liquid state

(1) Liquids do not have fixed shapes. It do not have fixed shapes and take up the shape of any container in which these are put.

(2) Liquids occupy definite volume or keep their volume. Though the liquids do not have definite shape, but they do have definite volume. This means that like a solid, a liquid cannot be compressed on applying pressure. Actually, the intermolecular forces in the liquids are so strong that the pressure which is applied, is not in a position to overcome these. The liquids therefore keep their volume.

(3) Liquid have fluidity and not rigidity. Unlike solids, the liquids have fluidity and not rigidity i.e. they have tendency to flow. This is due to lesser interparticle or intermolecular forces that are present in the liquid state as compared to the solid state. However, the liquids differ in their relative fluidity. For example, water flows at a faster rate than honey because in honey. the particles are heavier and also more closely packed.

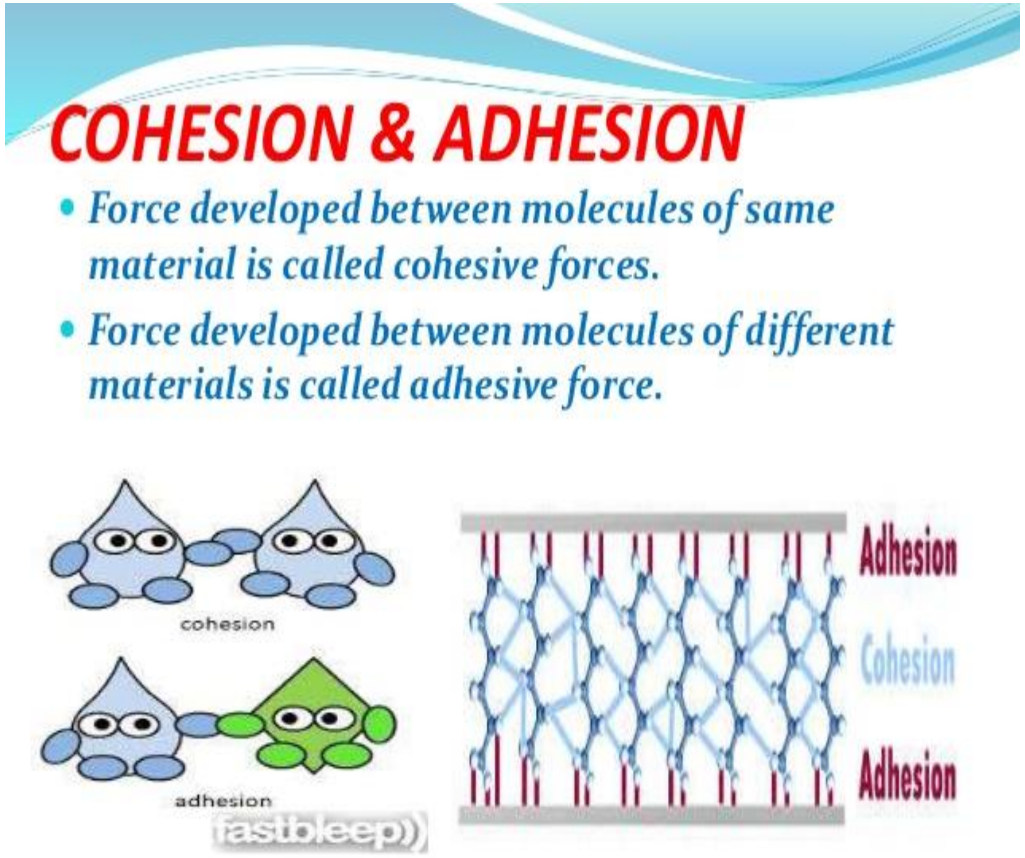
(4) Liquids have lesser density as compared to solids. As compared to solids, liquids are generally light. This is on account of greater number of interparticle spaces in the liquid state as compared to the solid state of the same substance.

(5) The kinetic energy of the particles in the liquid state is more than in the solid state. The particles in the liquid state are less closely packed as compared to the solid state. As a result, the interparticle forces are weaker. Therefore, the kinetic energy of the particles in the liquid state of a substance is more than in solid state. It further increases with the rise in temperature.

(6) Particles in the liquid state can easily diffuse. Due to lesser interparticle forces of attraction, the particles in a liquid state can diffuse more readily than the solid state of a substance. This also helps in the intermixing of certain liquids. For example, water and alcohol are both liquids and can easily mix to form a liquid mixture or solution.

For example, **Water, alcohol, milk, diesel, petrol, kerosene oil, Vegetable oil, fruit juices, etc.**

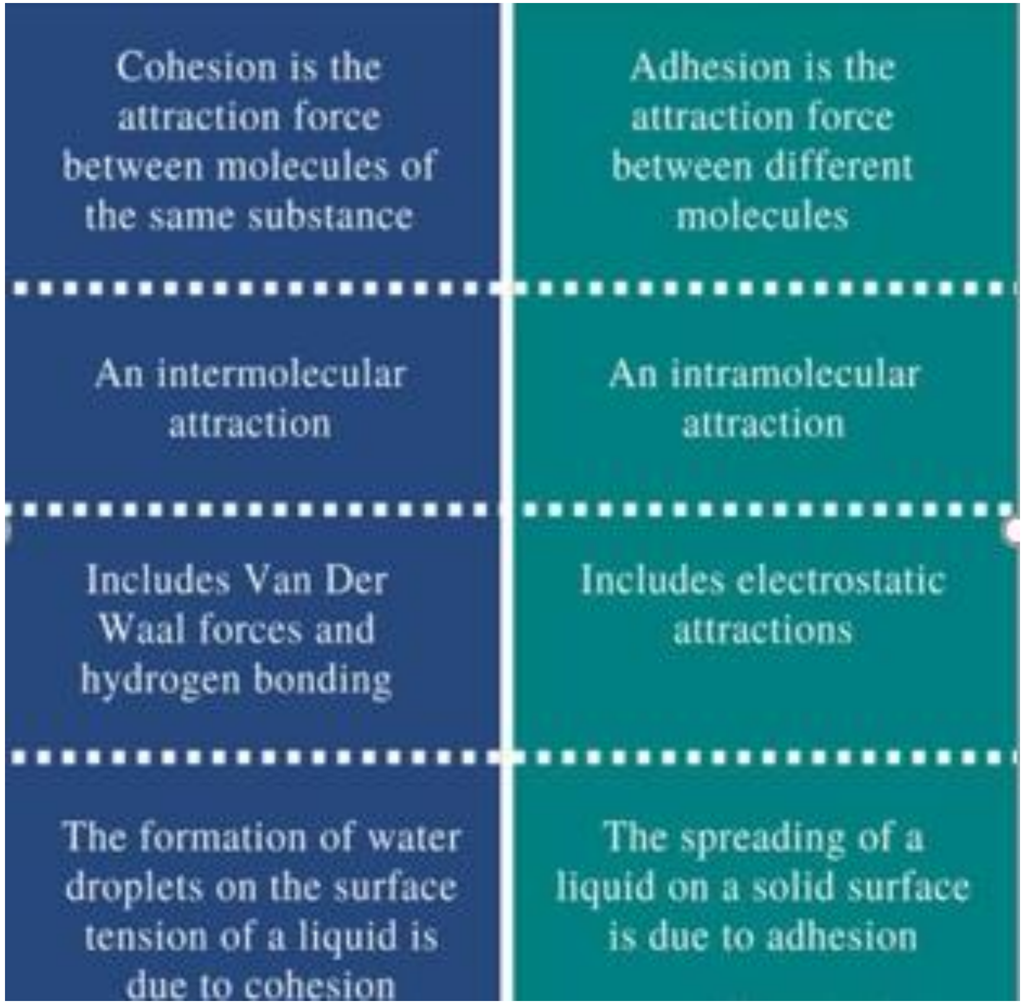
TYPES OF FORCE OF ATTRACTION



COHESION & ADHESION

- *Force developed between molecules of same material is called cohesive forces.*
- *Force developed between molecules of different materials is called adhesive force.*

cohesion
adhesion
fastbleep))
Adhesion
Cohesion
Adhesion



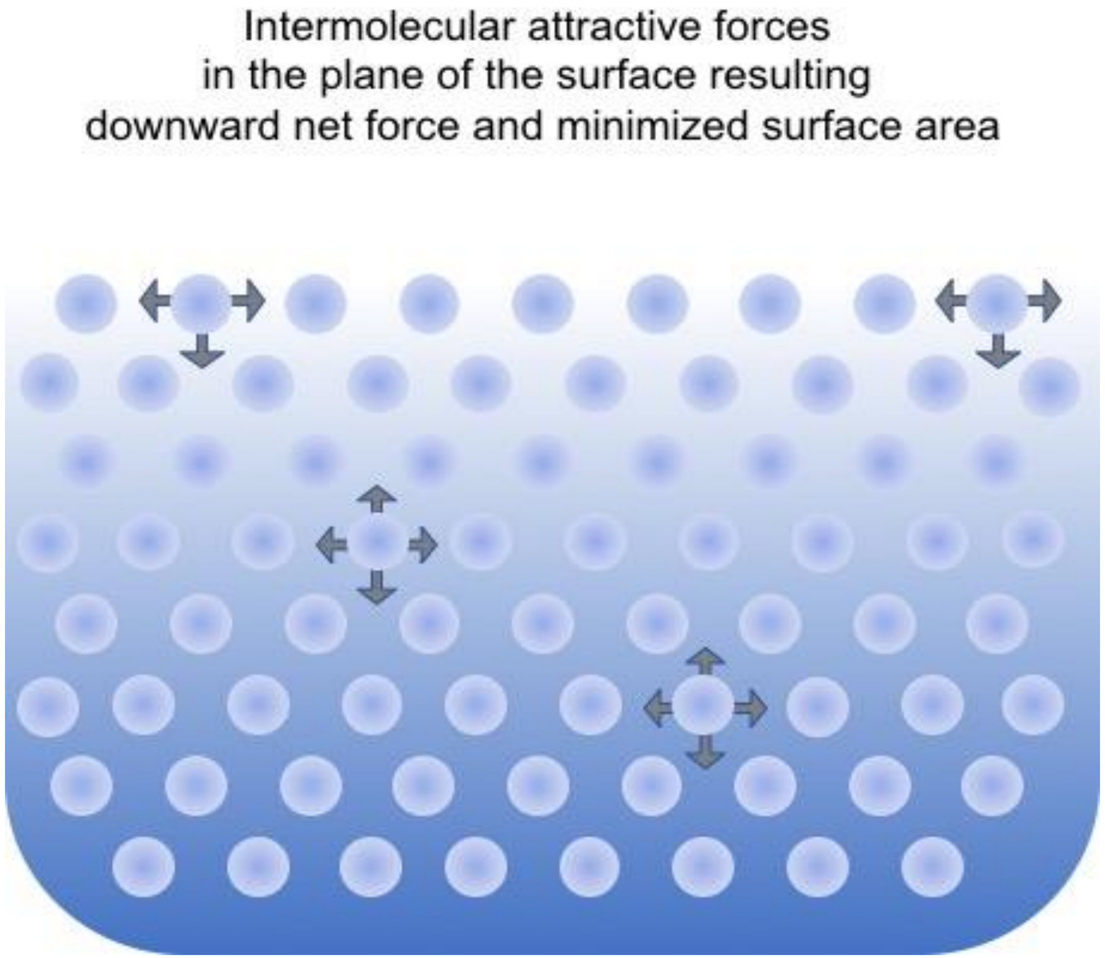
Cohesion is the attraction force between molecules of the same substance	Adhesion is the attraction force between different molecules
An intermolecular attraction	An intramolecular attraction
Includes Van Der Waal forces and hydrogen bonding	Includes electrostatic attractions
The formation of water droplets on the surface tension of a liquid is due to cohesion	The spreading of a liquid on a solid surface is due to adhesion

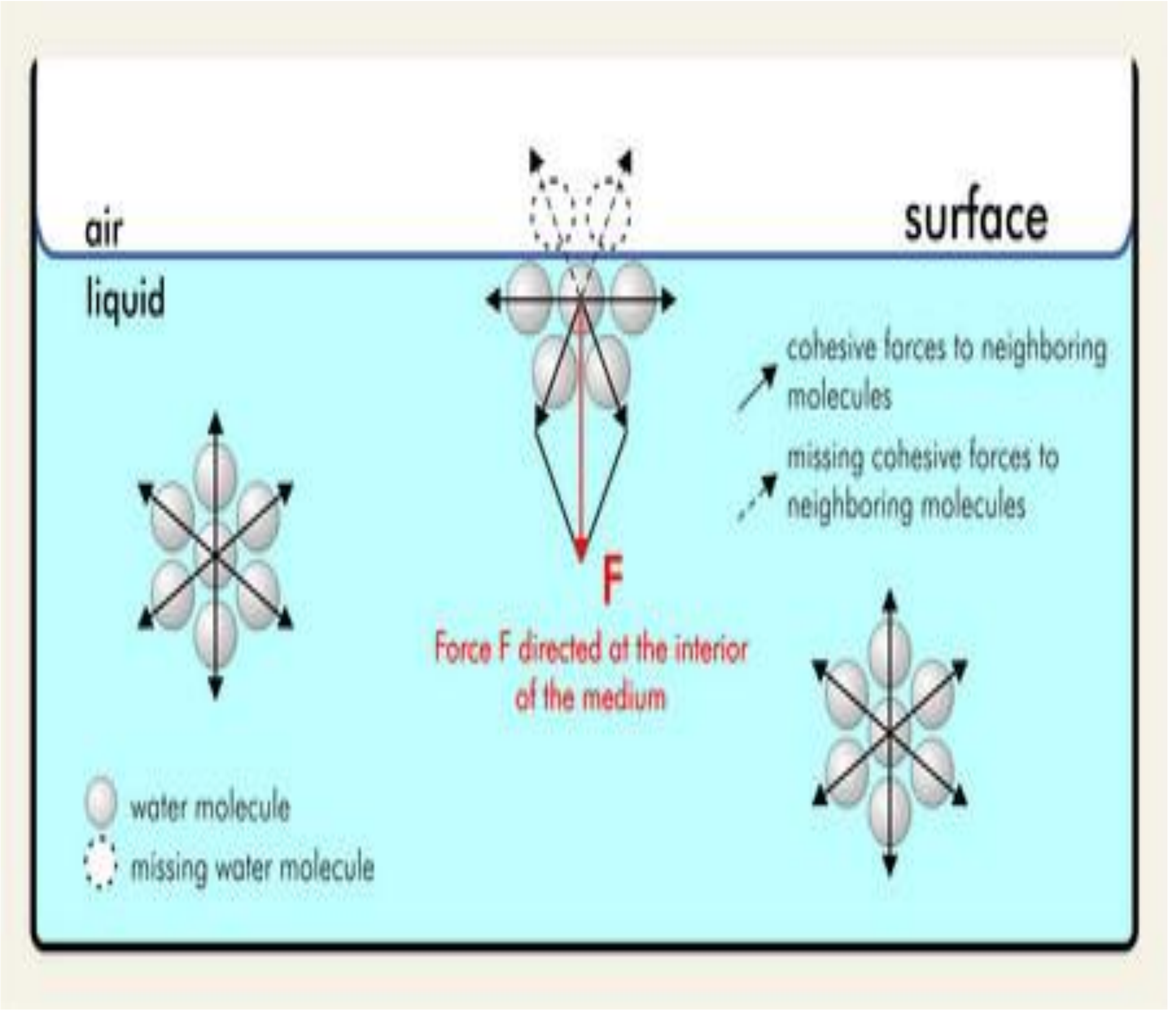
Some important properties of liquid

1. Surface tension

2. Viscosity

Surface Tension


Intermolecular attractive forces
in the plane of the surface resulting
downward net force and minimized surface area


air
surface
liquid
cohesive forces to neighboring molecules
missing cohesive forces to neighboring molecules
F
Force F directed at the interior of the medium
water molecule
missing water molecule

The molecules in liquids are held together closely by inter molecular force of attraction. A molecule in the bulk of the liquid is attracted equally on all the sides so that the net attractive pull on the molecule is zero. However, a molecule which lies at the surface is subjected only to the attractive forces of the molecules below it. This is because there are no molecules above it. Therefore, surface molecules experience a resultant downward attractive force within the liquid. This creates an imbalance of forces at the surface. In other words, the liquid surface is under tension due to unbalanced forces. The effect is called **surface tension.**

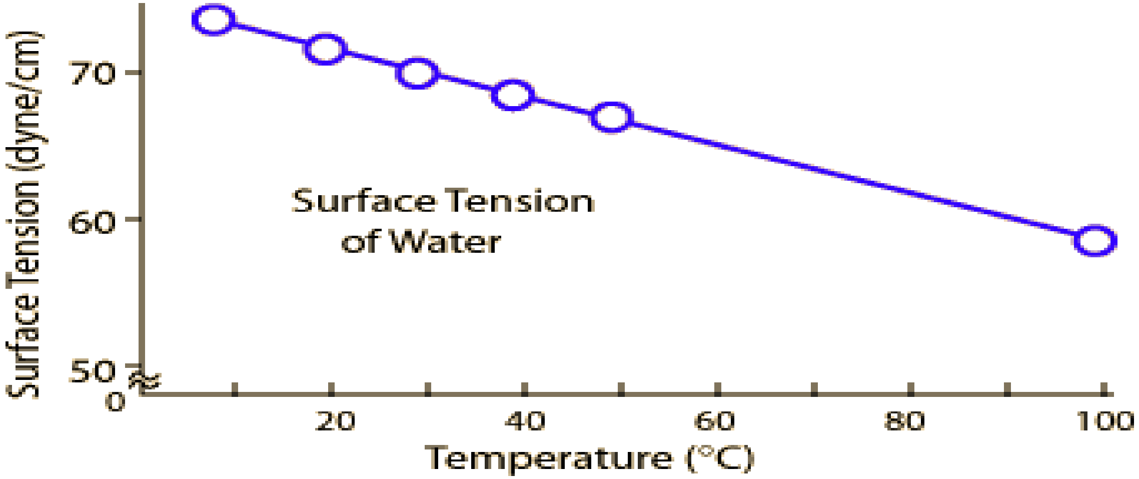
Factors affecting surface tension

1. Effect of temperature

Surface tension decreases with rise of temperature.

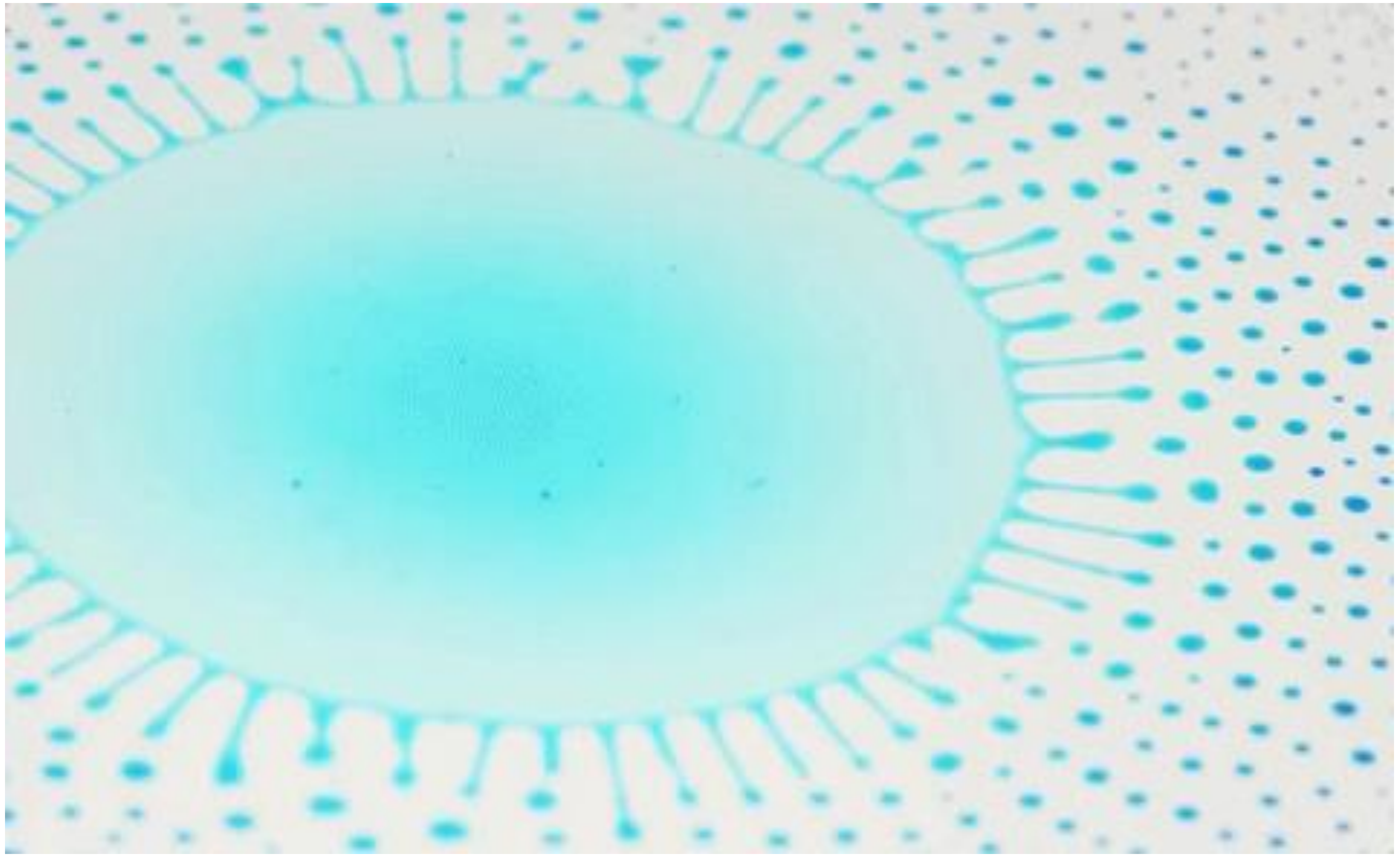
WHY??????

The kinetic energy of molecules increases due to increase of temperature. So, intermolecular forces decreases as a result surface tension decreases.



2. Nature of Liquid

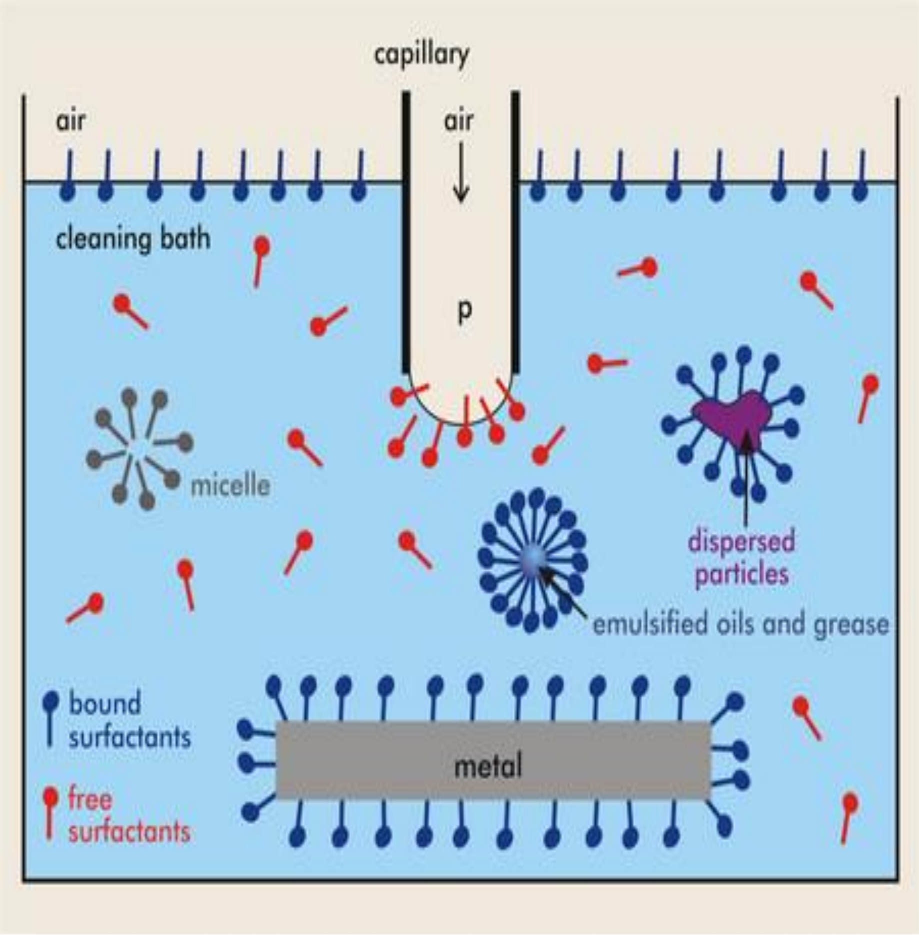
Liquids with more intermolecular forces will have large surface tension.



Importance of Surface tension

1.Capillary action

When one end of a capillary tube is put into liquid that wets glass, the liquid rises into the capillary tube to a certain height and then stops. The rise of liquid in capillary is Called capillary action.



2. Spherical shapes of drops

Surface tension tries to decrease the surface area of liquid.

Viscosity

- Resistance of a **fluid** (liquid or gas) to a change in shape, or **movement** of neighbouring portions relative to one another.
- Viscosity denotes opposition to flow.
- The **reciprocal** of the viscosity is called the **fluidity**, a measure of the ease of flow.
- **Molasses**, for example, has a greater viscosity than **water**.
- Because part of a fluid that is forced to move carries along to some extent adjacent parts, viscosity may be thought of as internal friction between the molecules; such friction opposes the development of velocity differences within a fluid.

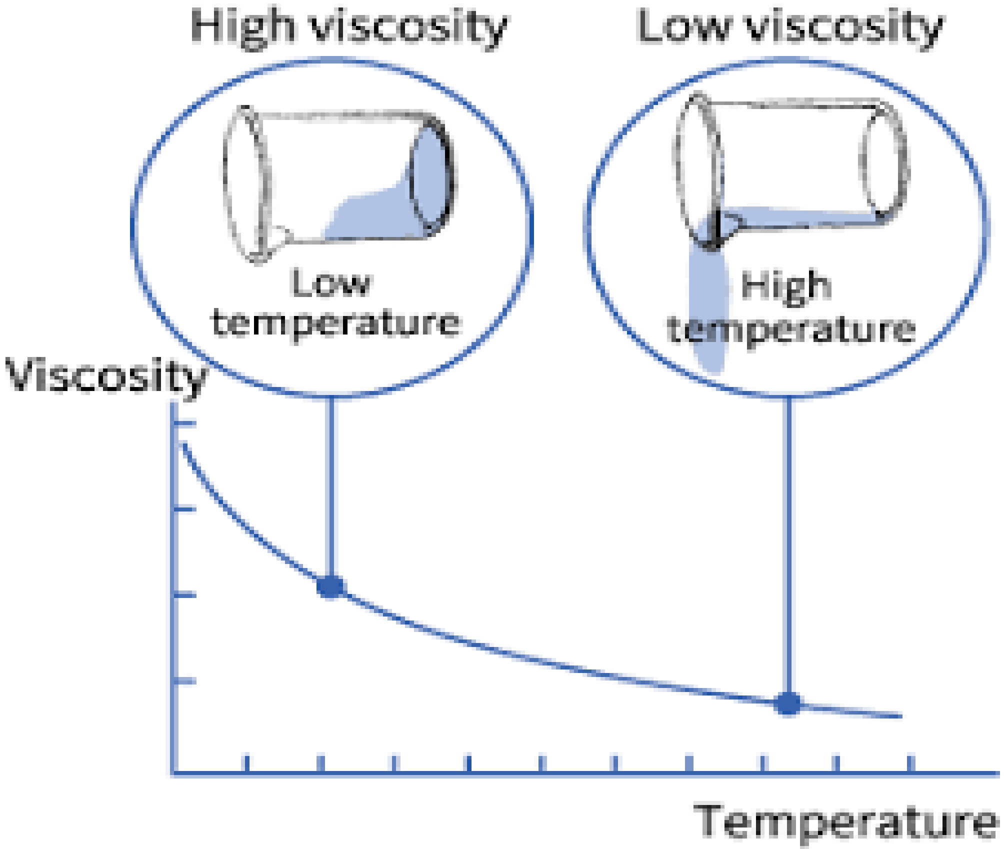
Factors affecting viscosity

Effect of temperature

Viscosity decreases with rise of temperature.

WHY??????

The kinetic energy of molecules increases due to increase of temperature. So, intermolecular forces decreases as a result viscosity decreases.



2. Nature of Liquid

Liquids with more intermolecular forces will have more viscosity.

Importance of Viscosity

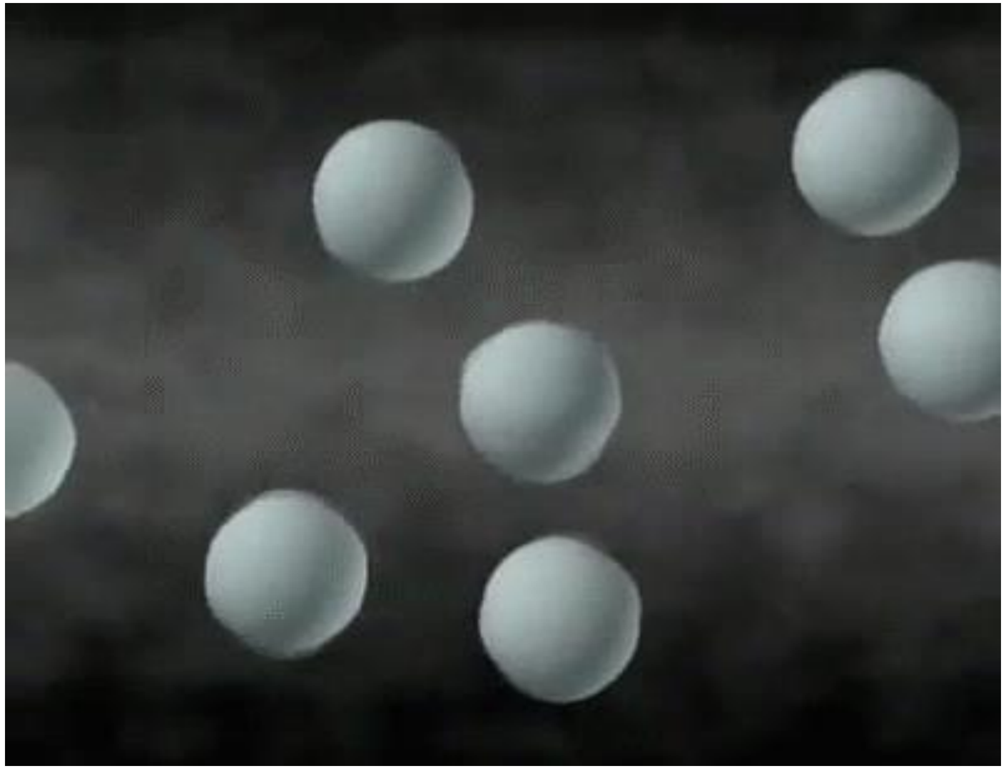
1. The shape of ships, aeroplanes, rockets are designed in such a way that they have least effect on their velocity due to friction of water and air.

2. To decrease friction in machines, suitable lubricants are selected on the basis of viscosity.

3. Viscosity is very helpful in determining the pressure required for sending liquids like petrol, water, etc. through pipe lines.

THE GASEOUS STATE

The gaseous state out of the three states of matter, the interparticle spaces are the maximum in the gaseous state. The interparticle forces which hold the different particles in the gaseous state together are the minimum. As a result, rigidity is the minimum while fluidity is the maximum.



Characteristics of gaseous state

(1)Gases do not have fixed shape. Gases do not have any shape of their own. They acquire the shape of the container in which they are filled or kept.

(2) Gases have maximum fluidity and least rigidity. Since the interparticle spaces are the maximum in the gaseous state, the attractive forces are the least. As a result, the fluidity is very large while rigidity is negligible.

(3) Gases do not have fixed volume and are highly compressible. Since the interparticle distances in the gaseous state are very large, they can be changed(increased or decreased) by altering the pressure. Thus, a gas can be compressed to a large extent on applying pressure. This means that change in pressure can bring a change in volume or we can say that gases do not keep their volume.

(4) Density of gases is very less. Due to large interparticle spaces. particles of gas are far separated and volume of a given mass of a gas is quite large. Therefore, density becomes lens and gases are thus, light.

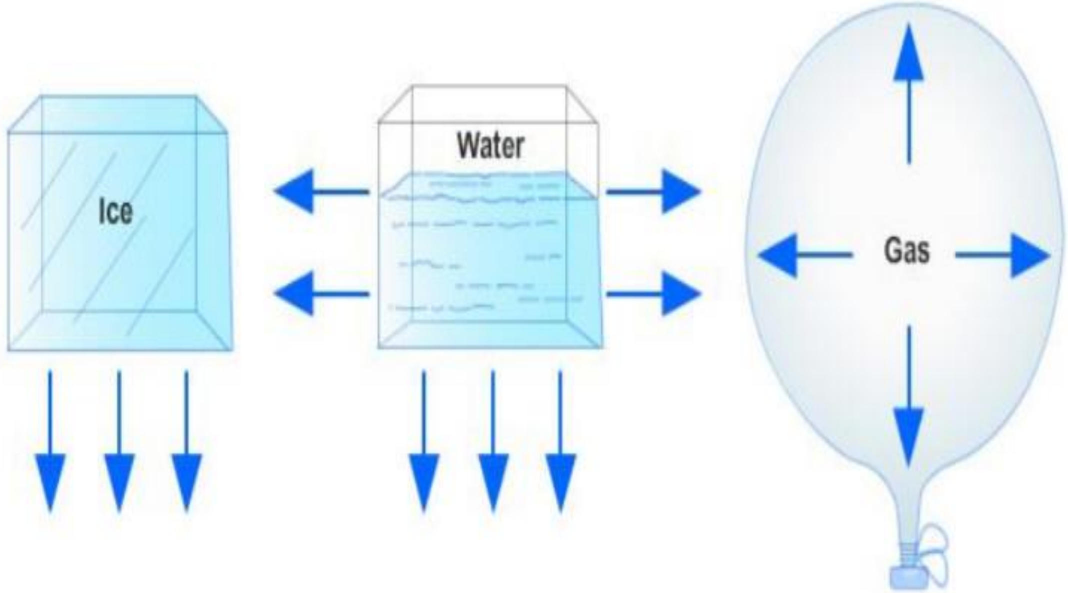
(5) The kinetic energy of the particles in the gaseous state is very high. The interparticle forces are very weak. As a result the particles or the molecules of a gas can move quite freely from one place to another. That means there translational motion is large and kinetic energy is quite high. It can further increase when the temperature of the gas is increased.

(6) Gases exert pressure. Since particles in a gas have high kinetic energy, they strike the walls of the container with force. As a result, they exert pressure. Please note that greater the number of hits recorded per unit area of the wall of the container, more will be the pressure of the gas, which depends on the energy of particles.

(7) Gases diffuse very rapidly. Since the interparticle spaces are very large and interparticle forces are quite weak, the particles of one gas can readily move into the empty spaces of another gas.

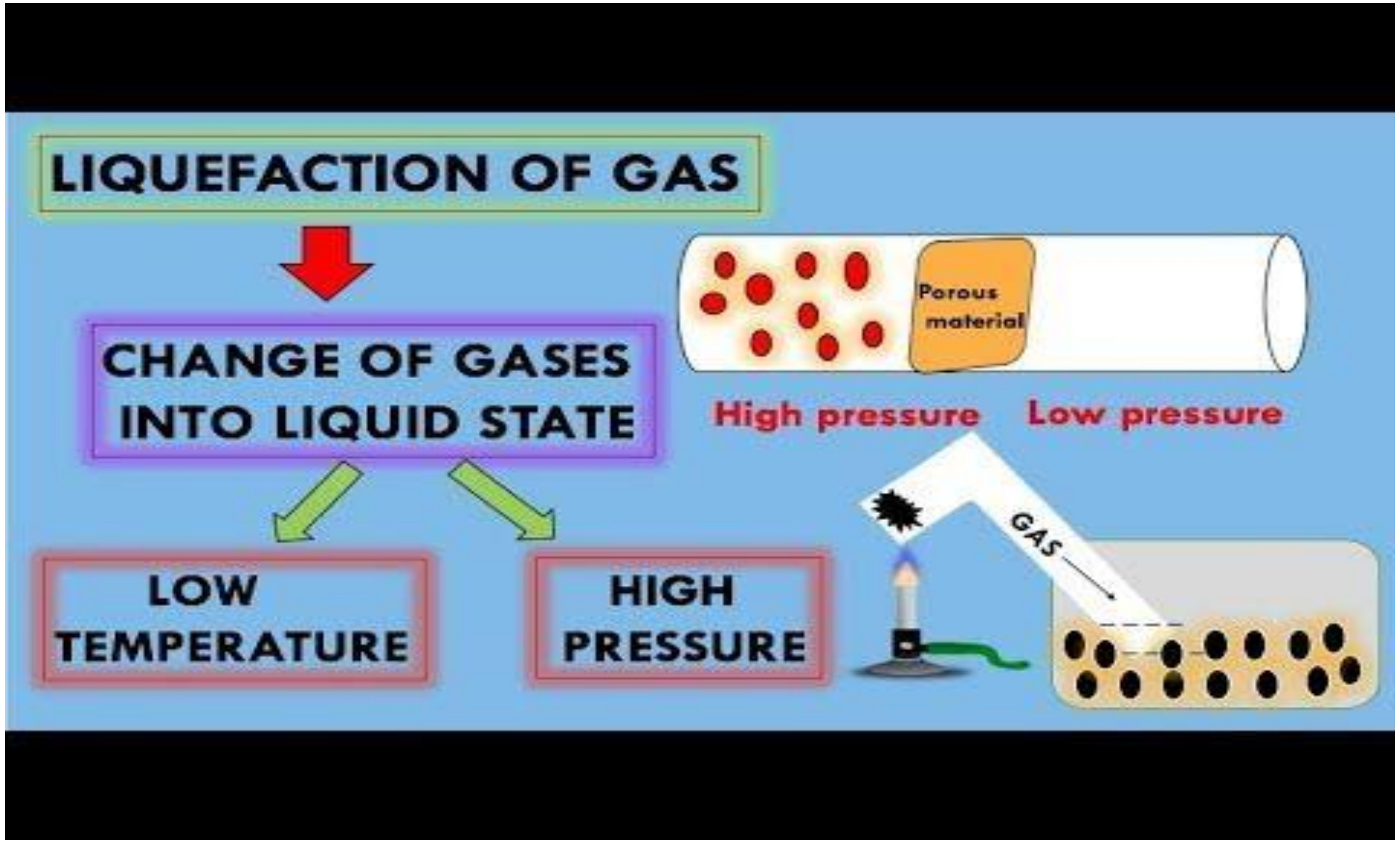
Exertion of pressure

- **Solid** exert pressure only in downward direction.
- **Liquids** exert pressure downward as well as to the sides.
- **Gases** exert pressure in all directions.
- This pressure is due to bombardment or the particles against the walls of the container.



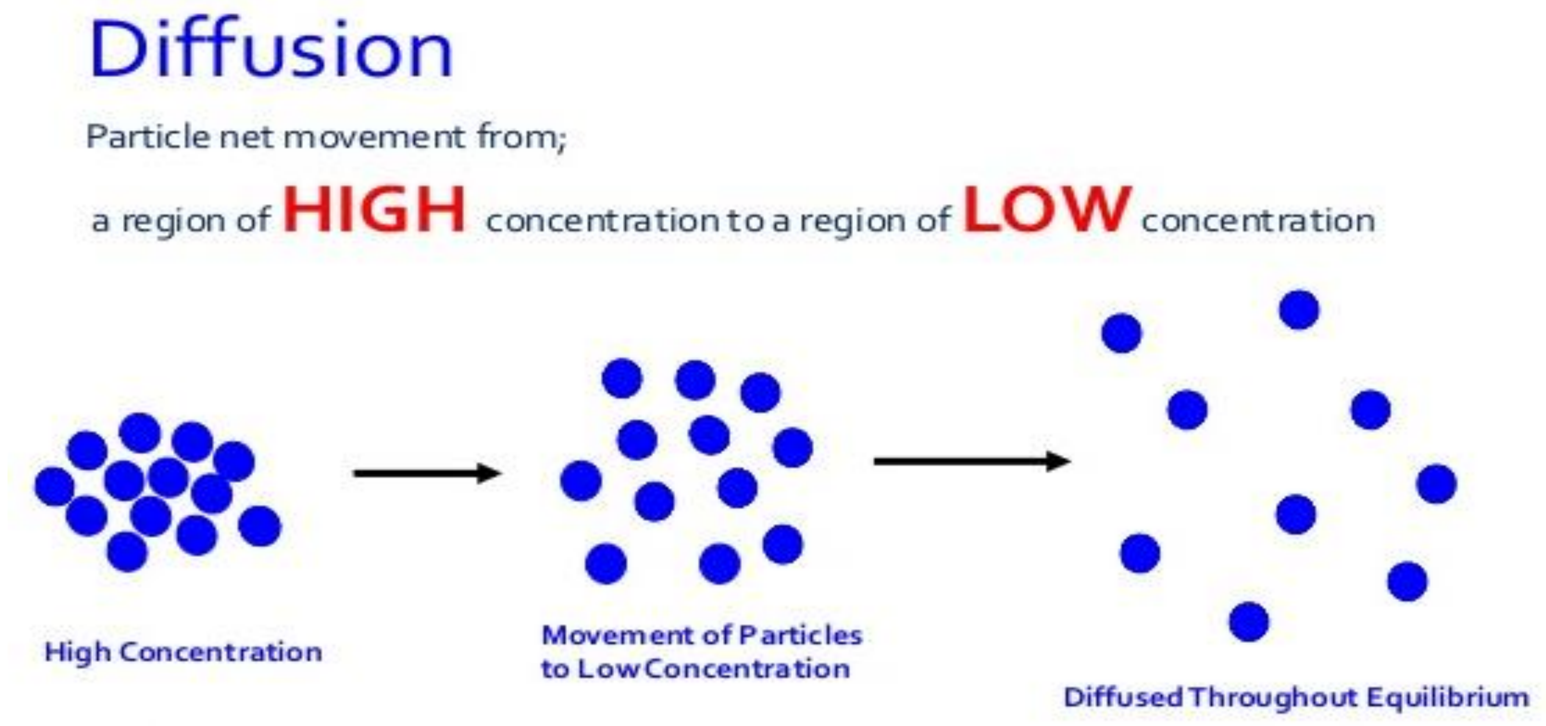
Liquefaction

Gases can be liquefied by cooling and by applying pressure.



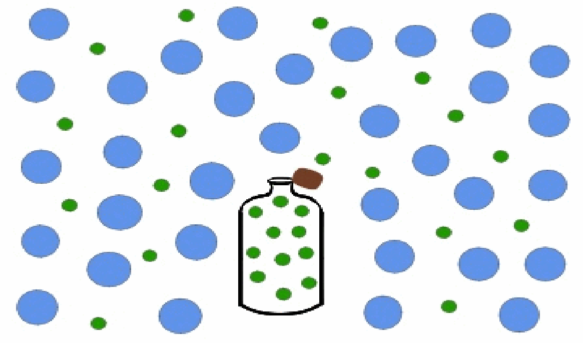
Diffusion

The spontaneous intermixing of particles of two or more different substances is called diffusion.


Diffusion
Particle net movement from;
a region of HIGH concentration to a region of LOW concentration
High Concentration
Movement of Particles to Low Concentration
Diffused Throughout Equilibrium

Examples

1. When a bottle of ammonia is opened in one corner of the laboratory, its pungent smell can be experienced all over the laboratory.



2. When a bottle of perfume is opened in the drawing room its smell spreads and can be detected all over the room.

Uses of gaseous diffusion

(1) **Separation of gases:** Gases can be separated from the mixture of gases by the use of process of diffusion. When a mixture of gases is diffused, the lighter gases will diffuse quickly than the heavier gases. In this way by repeating the process of diffusion, gases can be separated from the mixture.

(2) **Relative densities and molecular weights of the gases:** Graham's Law of diffusion can be used for the determination of relative densities and molecular weights of the gases.

Building concepts

1. Explain why a gas fills completely the vessel, in which it is kept?

Explanation

The molecules of a gas have large intermolecular spaces and kinetic energy, but extremely small intermolecular forces. Thus, the molecules of the gas spread in the entire space of the containing vessel on account of high kinetic energy and practically low intermolecular forces, hence fill entire space of the vessel.

Comparison of Solids, Liquids & Gases

Properties	Solids	Liquids	Gases
Mass	Definite	Definite	Definite
Shape	Definite	Acquires the shape of the container	Acquires the shape of the container
Volume	Definite	Definite	Indefinite
Compressibility	Not possible	Almost negligible	Highly Compressible
Fluidity	Not possible	Can flow	Can flow
Rigidity	Highly rigid	Less rigid	Not rigid
Diffusion	Slow	Fast	Very fast
Space between particles	Most closely packed	Less closely packed	Least closely packed
Interparticle force	Strongest	Slightly weaker than in solids	Negligible

CAN MATTER CHANGE ITS STATE?????

What happens inside the matter during this change of states?

What happens to the particles of matter during the change of states?

How does this change of state take place?

If YES then,

What are the factors responsible for change in state??????????????

$$\text{Ice} \xrightarrow{\text{Heat}} \text{Water} \xrightarrow{\text{Heat}} \text{Steam}$$

(solid) (Liquid) (Gas)

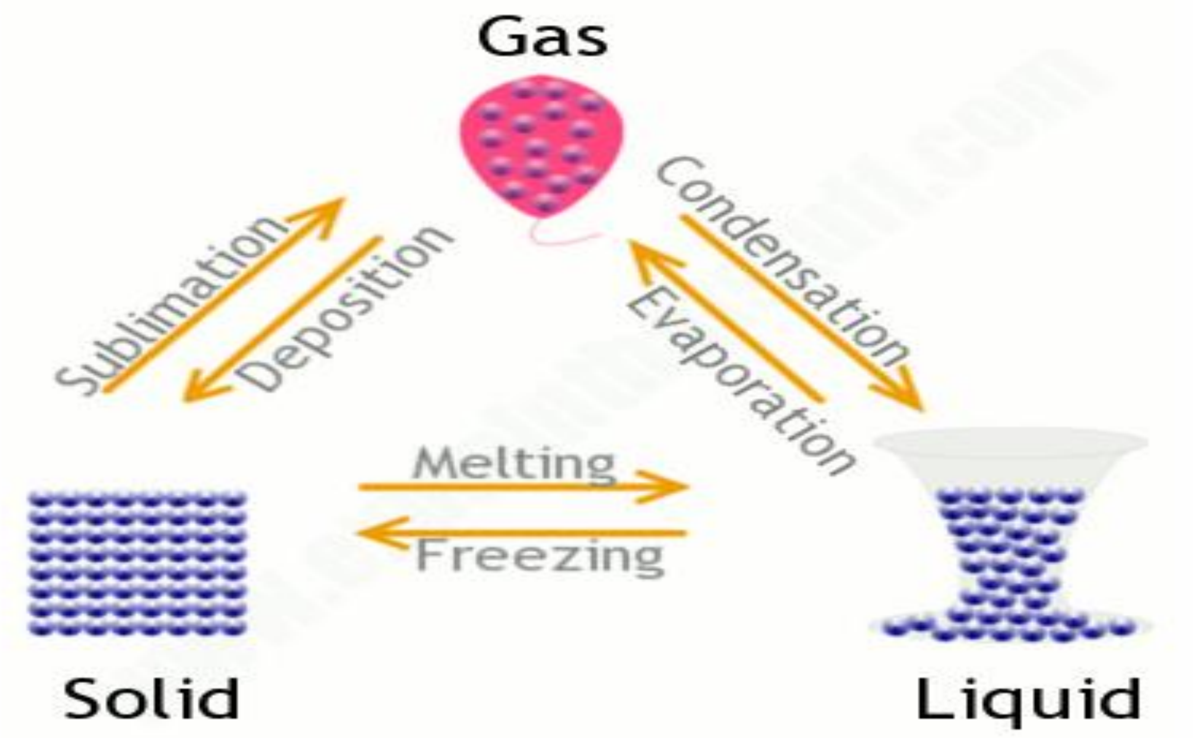
ALLEN®
Mumbai, Maharashtra

INTERCONVERSION OF STATES OF MATTER

Two factors are responsible

1. Temperature

2. Pressure



Effect of TEMPERATURE

Temperature is defined as degree of hotness or coldness of an object.

Temperature affects the phase of matter by breaking the bonds between the molecules of a substance, leading it to change its state.

- **Melting**
- **Freezing**
- **Boiling**
- **Condensation**
- **Sublimation**

1.Melting

Solid to liquid:

On increasing the temperature of solids, the kinetic energy of the particles increases which overcomes the forces of attraction between the particles thereby solid gets converted to a liquid.

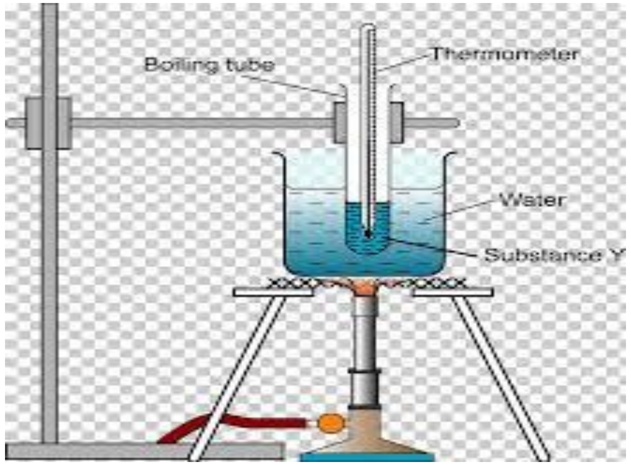
Melting: Change of solid state of a substance into liquid is called melting.

Melting point: The temperature at which a solid melts to become a liquid at the atmospheric pressure is called its melting point.

Melting point of ice is 0°C.

Note:

Temperature remains constant during melting or boiling i.e. during conversion of solid to liquid and liquid to vapors.



FACTORS AFFECTING MELTING POINT

1. EFFECT OF PRESSURE ON MELTING POINT

Melting point of substances that **contract on melting** (like ice) decreases with increase in pressure. This is because increase in pressure favors contraction.

Examples: Ice, cast iron, brass, etc.

Melting point of substances that **expand on melting** (like lead) increases with increase in pressure. This is because increase in pressure opposes expansion.

Examples: Paraffin wax, silver, gold and copper.

ACTIVITY

- Take two pieces of ice cubes and that are pressed together with application of pressure by hand.
- Now see on applying pressure its melting point decreases and when this pressure is released it solidifies in single piece.
- This principle is called **regelation**.

2. EFFECT OF ADDITION OF IMPURITIES

Melting point of a substance decreases by the presence of impurities in it. This phenomenon is used in making the freezing mixture by adding salt to ice.

Examples:

Rose's metal (Alloy of tin, lead and bismuth)

Melting point of this alloy is 94.5°C

Individual melting points are:

Pb- 327 °C

Sn- 231.9 °C

Bi- 271 °C

Temperature Scales

1. Celsius
2. Kelvin
3. Fahrenheit

Conversion of temperature on Celsius scale to Kelvin scale

For example, O°C = 0 + 273 = 273K
100°C = 100 + 273 = 373K

Question: Convert the following temperature to the Kelvin scale.
(a) 27 °C
(b) 378 °C

Answer:
(a) 300 K
(b) 651 K

Conversion of temperature on Kelvin scale to Celsius scale

For example, 373K = 373 - 273 = 100 °C
273K = 273 - 273 = 0 °C

Question: Convert the following temperature to the Celsius scale.
(a) 300K
(b) 573K

Answer:
(a) 27 °C
(b) 300 °C

Temperature Scales

Conversion of temperature on Celsius scale to Fahrenheit scale

Formula: 9/5(°C) = °F - 32

For example, 10O°C to °F
Then 9/5 (100 °C) = °F - 32
°F = (9 x 20) + 32
°F = 212

Question: Convert the following temperature to the Fahrenheit scale.
(a) 27 °C
(b) 378 °C
Answer:
(a) 80.6 °F
(b) 712.4°F

2. Freezing

Liquid to solid:

When a liquid is cooled down by lowering its temperature, its particles lose the kinetic energy and come to a stationary position, causing the liquid to turn to solid.

Freezing: The change of a liquid substance into solid by lowering its temperature is called freezing.

Freezing point: The temperature at which the state of a substance changes from a liquid to a solid is called the freezing point of that substance.

FACTORS AFFECTING FREEZING POINT

On adding impurities freezing point decreases.

A mixture of 3 parts of ice and 1 part of common salt is called **freezing mixture**, which lowers the temperature to -21 °C. Freezing mixtures are used for preservation of food especially perishables such as fish, meats and other ready to eat frozen food.

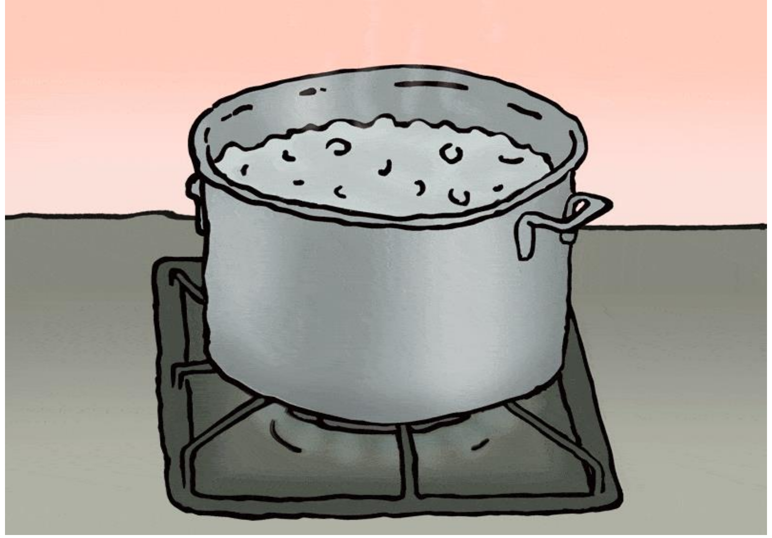
Note:

Freezing point of a liquid is the same as the melting point of its solid state.

For example, the freezing point of water is 0°C which is the same as the melting point of ice.

Unique nature of ICE

- As water cools, its molecular motion slows and the molecules move gradually closer to one another. The **density** of any liquid increases as its temperature decreases. For most liquids, this continues as the liquid freezes and the solid state is denser than the liquid state. However, water behaves differently. It actually reaches its highest density at about 4°C.
- Between 4°C and 0°C, the density gradually decreases as the hydrogen bonds begin to form a network characterized by a generally **hexagonal** structure with open spaces in the middle of the hexagons.
- Ice is less dense than liquid water and so it floats. Ponds or lakes begin to freeze at the surface, closer to the cold air. A layer of ice forms, but does not sink as it would if water did not have this unique structure dictated by its shape, polarity, and hydrogen bonding. If the ice were to sink as it froze, entire lakes would freeze solid. Since the ice does not sink, liquid water remains under the ice all winter long. This is important, as fish and other organisms are capable of surviving through winter. Ice is one of only a very few solids that is less dense than its liquid form.



3. Boiling

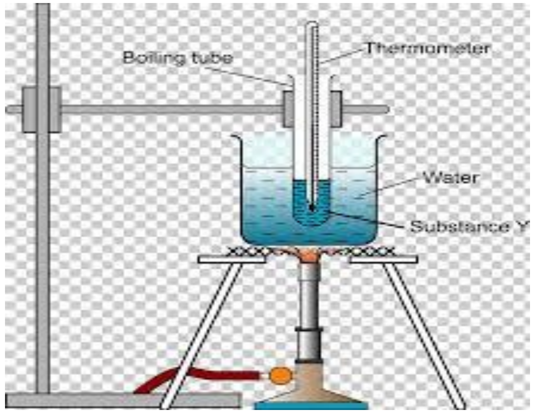
Liquid to gas:

On heating a liquid like water, the kinetic energy of its particles increases as high as in a gas, thus causing the liquid to change to a gas.

Boiling: The change of a liquid substance into gas on heating is called boiling.

Boiling point: The temperature at which a liquid boils and changes rapidly into a gas at the atmospheric pressure is called its boiling point.

Boiling point of water is 100°C.



FACTORS AFFECTING BOILING POINT

1. EFFECT OF PRESSURE ON BOILING POINT

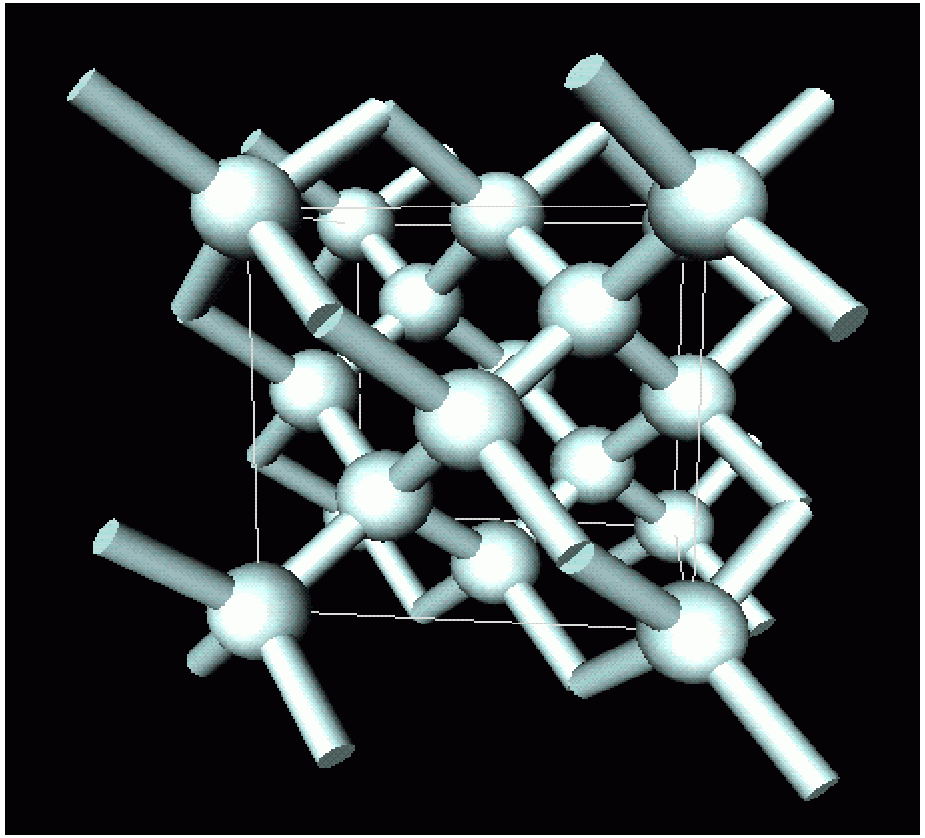
The boiling point of a liquid increases with increase in pressure. Hence, cooking at high altitudes is difficult.

2. EFFECT OF IMPURITIES ON BOILING POINT

Boiling point of a liquid increases with addition of impurities in it. Hence, cooking is better when salt is added to the water.

Note:

Melting point and boiling point are measures of strength of forces of attraction between constituent particles. Higher the melting point and boiling point, stronger is the forces of attraction.



Latent heat: The heat energy that is required to change the state of a substance without causing any rise in the temperature of the substance is called latent heat. Since, the heat energy is hidden in the bulk of the matter, it is called latent heat.

Latent heat of fusion: The heat energy required to convert 1 kilogram of a **solid into liquid** at atmospheric pressure, at its melting point, is known as the latent heat of fusion.

The latent heat of fusion of ice is **3.34×10^5 J/kg.**

Latent heat of vaporisation: The heat energy required to convert 1 kilogram of **liquid into gas**, at atmospheric pressure, at its boiling point, is known as the latent heat of vaporisation.

The latent heat of vaporisation of water is **22.5×10^5 J/kg.**

Note:

Water vapour at 373 K have more energy than water at the same temperature because particles in steam have absorbed extra energy in the form of latent heat of vaporisation.

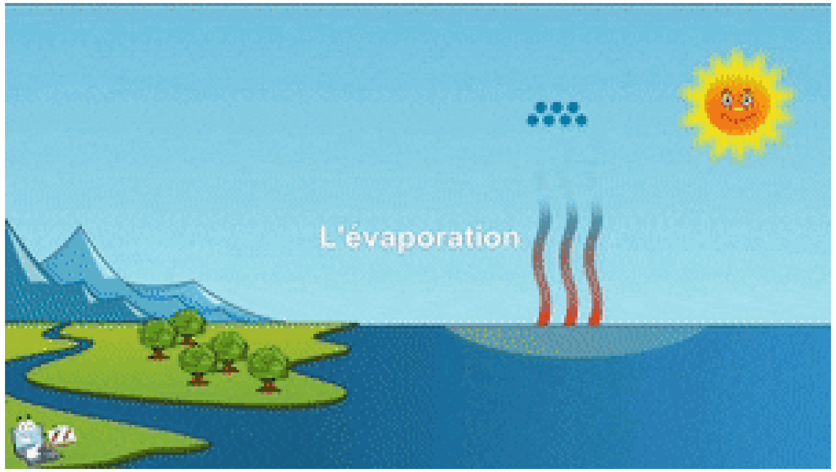
4. Condensation

Gas to liquid:

On cooling a gas like steam (or water vapour), the kinetic energy of its particles is lowered down, causing them to move slowly and bringing them closer, forming a liquid.

Condensation:

The process, in which a gas, on cooling, turns into a liquid at a specific temperature is called condensation or liquefaction.



- In the atmosphere, condensation may appear as clouds, fog, mist, dew or frost, depending upon the physical conditions of the atmosphere. Condensation is not a matter of one particular temperature but of a difference between two. Condensation of water vapour occurs when the temperature of air is lowered to its dew point.

- When air is cooled, relative humidity increases, until at a particular temperature, called the dew point, the air becomes saturated. Further cooling below the dew point will induce condensation of the excess water vapour.

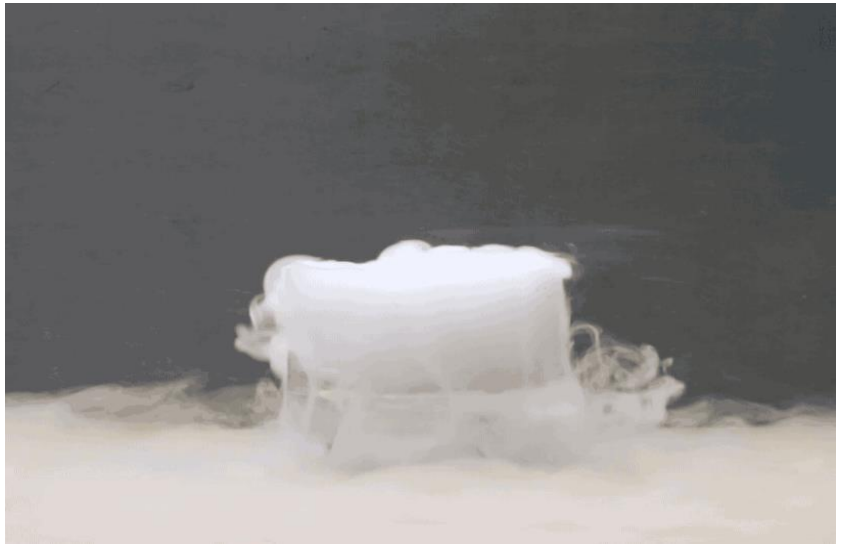
Condensation happens because of loss of energy. Gases are excited atoms. When they lose energy, they slow down and begin to collect. They can collect into one drop. Water condenses on the lid of pot when you boil water. It cools on the metal and become liquid again.

5. Sublimation

The change of state of a substance directly from a solid to gas or gas to solid, without changing into the liquid state, is called sublimation.

Sublime: A gaseous form, directly formed from a solid on heating, is known as sublime.

Sublimate: A solid state of matter formed directly from its gaseous state on cooling, is called sublimate.



youtube.com/atbristol

Examples of sublimation

i) In very cold places, the snow does not melt but sublimes directly to vapours.

ii) In frost-free refrigerators, ice on the walls of the freezer sublimes when warm air is circulated through the compartment during the defrost cycle.

Activity

Aim

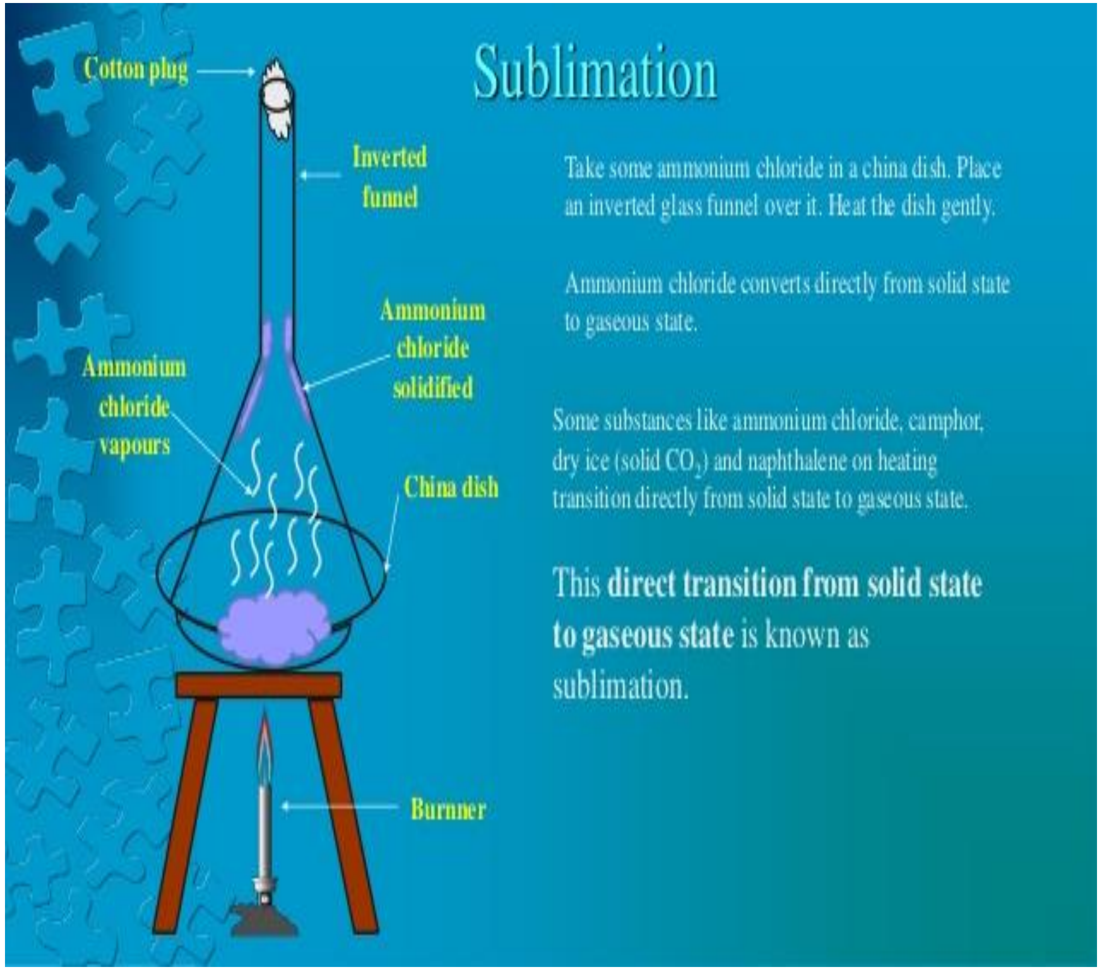
To demonstrate the process of sublimation.

Materials required

China dish, camphor or ammonium chloride, Funnel, cotton plug, burner, tripod stand and wire gauze.

Method

(a) Take some camphor or ammonium chloride.
(b) Powder it and put in a china dish.
(c) Place an inverted funnel over the china dish.
(d) Put a cotton plug on the stem of the funnel.
(e) Heat the china dish slowly.



Sublimation

Take some ammonium chloride in a china dish. Place an inverted glass funnel over it. Heat the dish gently.

Ammonium chloride converts directly from solid state to gaseous state.

Some substances like ammonium chloride, camphor, dry ice (solid CO_2) and naphthalene on heating transition directly from solid state to gaseous state.

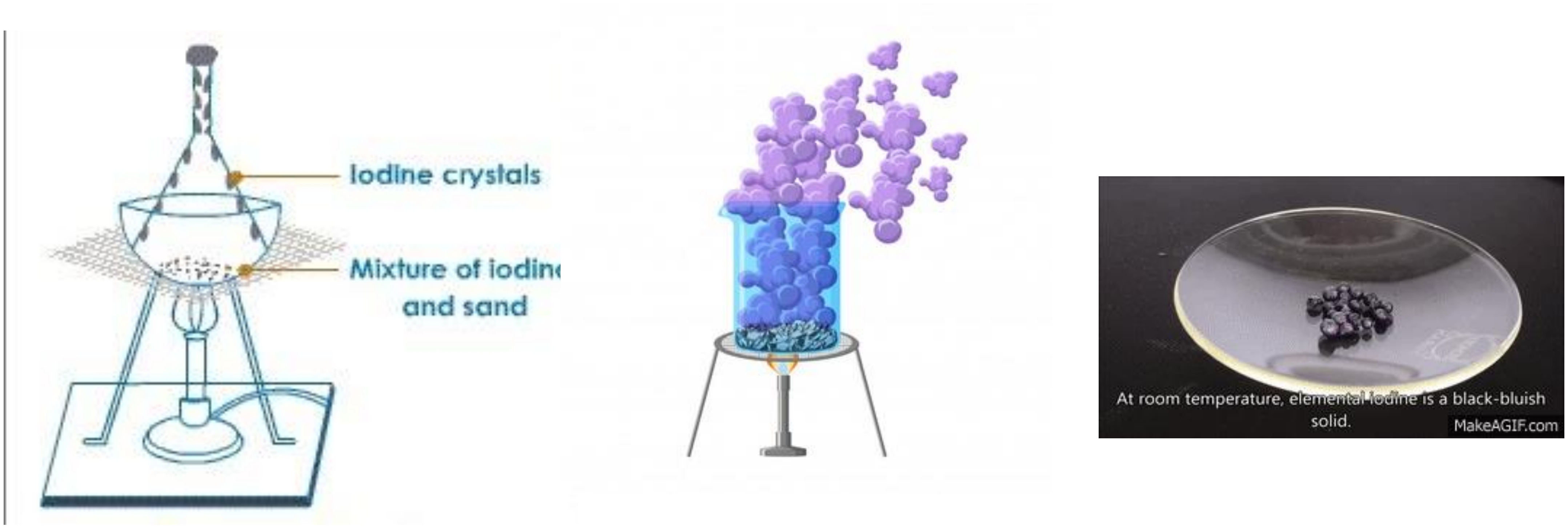
This direct transition from solid state to gaseous state is known as sublimation.

Observation

We observe that solid camphor on heating gets converted into vapour which gets condensed on the funnel. Solid state is directly converted into gaseous state.

Conclusion

This experiment shows sublimation process.


Iodine crystals
Mixture of iodin
and sand
At room temperature, elemental iodine is a black-bluish solid.
MakeAGIF.com

Sublimation of iodine crystals

Note:

1.**Condensation** is opposite to **evaporation** and **freezing** is opposite to **melting**.

2. The process of **melting** is called **fusion**.

3. The process of **freezing** is called **solidification**.

4. **Boiling** is also called **vaporization**.

5. **Condensation** is also known as **liquefaction**.

Effect of change of Pressure

The pressure of air in atmosphere is called atmosphere pressure.

The atmosphere pressure at sea level is 1 atmosphere and is taken as the normal atmosphere pressure.

Pressure = Force/Area

The S.I. unit of pressure is pascal (Pa) and the other units are atmosphere and bar.

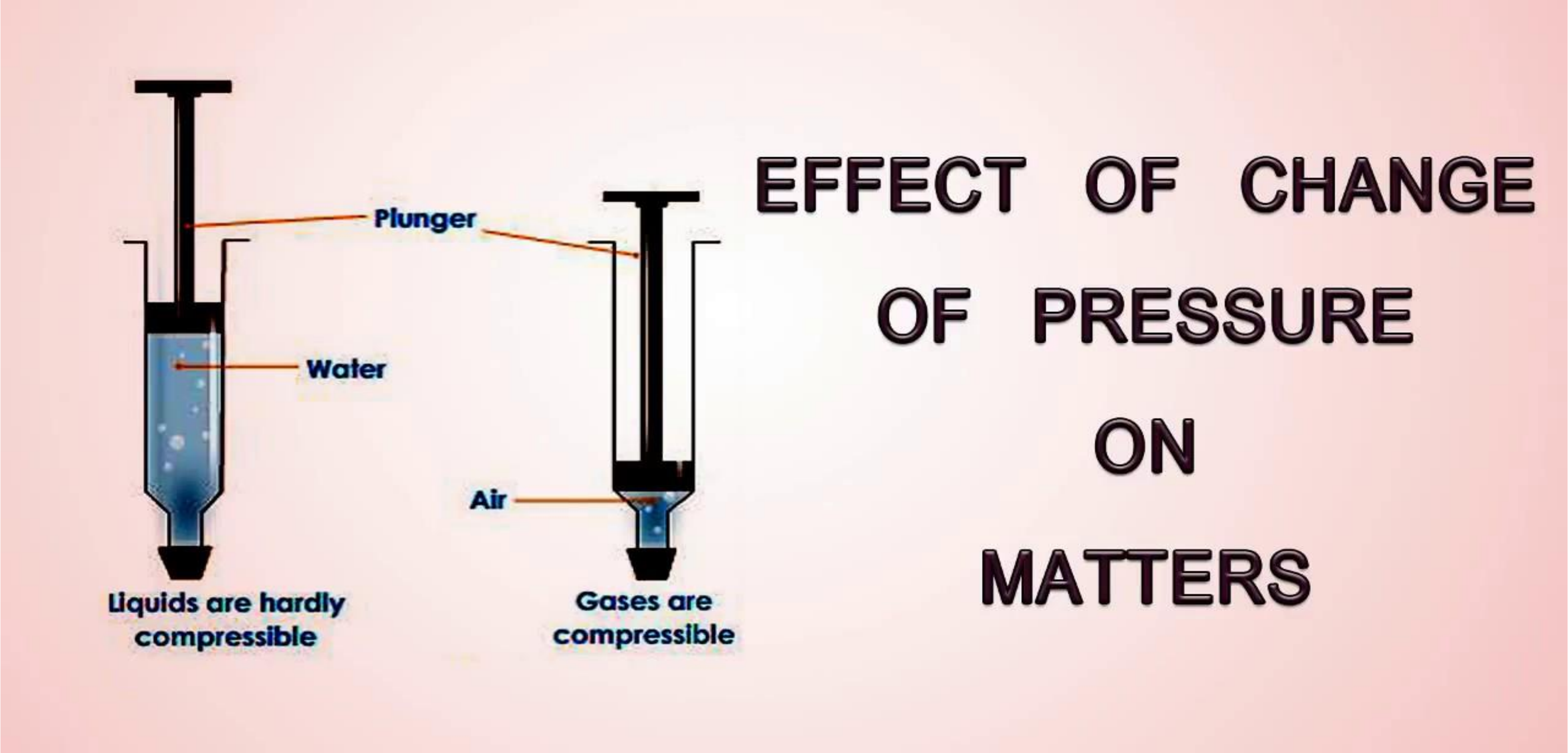
1 Atmosphere = 1.01 x 10^5 Pa, 1 bar = 0.987 atm.

To convert a gas into a liquid or to convert a liquid into a solid, the interparticle distances must be decreased and the interparticle forces of attraction must be made stronger. This can be done in the following ways:

(i) By applying pressure
(ii) By lowering temperature
(iii) By combination of both pressure and lowering temperature

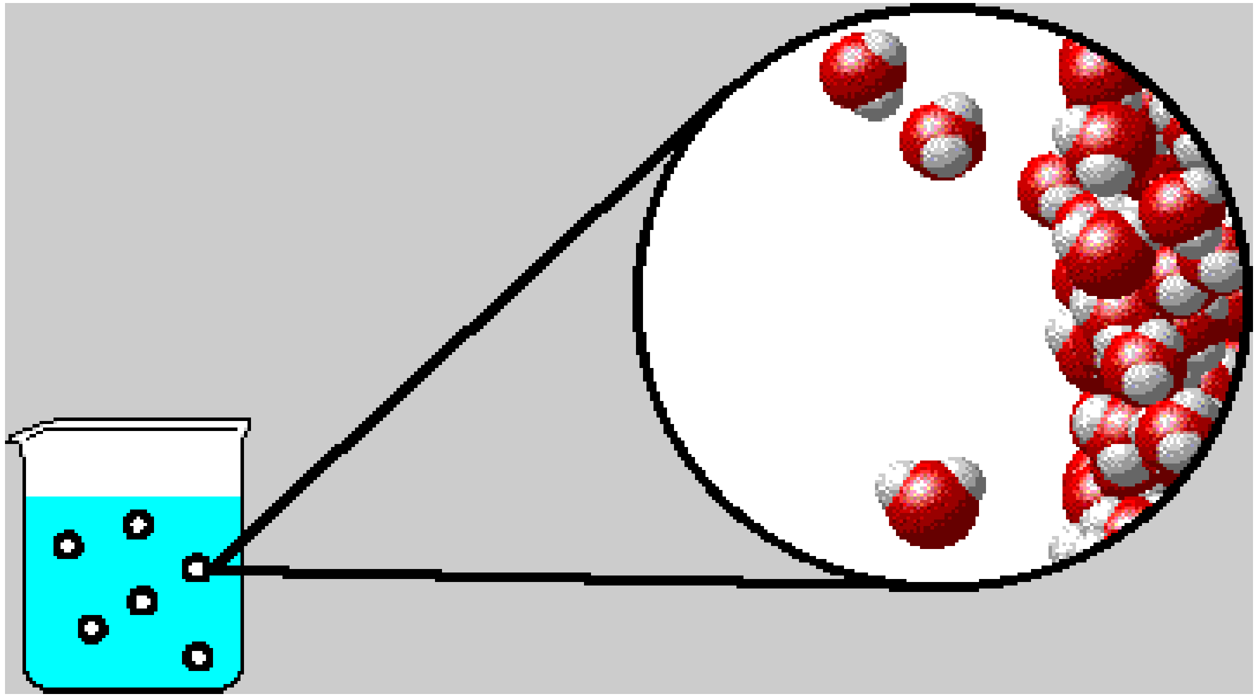
(i) By applying pressure

Gases are compressible because on applying pressure, the spaces between the gaseous particles decreases. Therefore gases can be compressed readily.



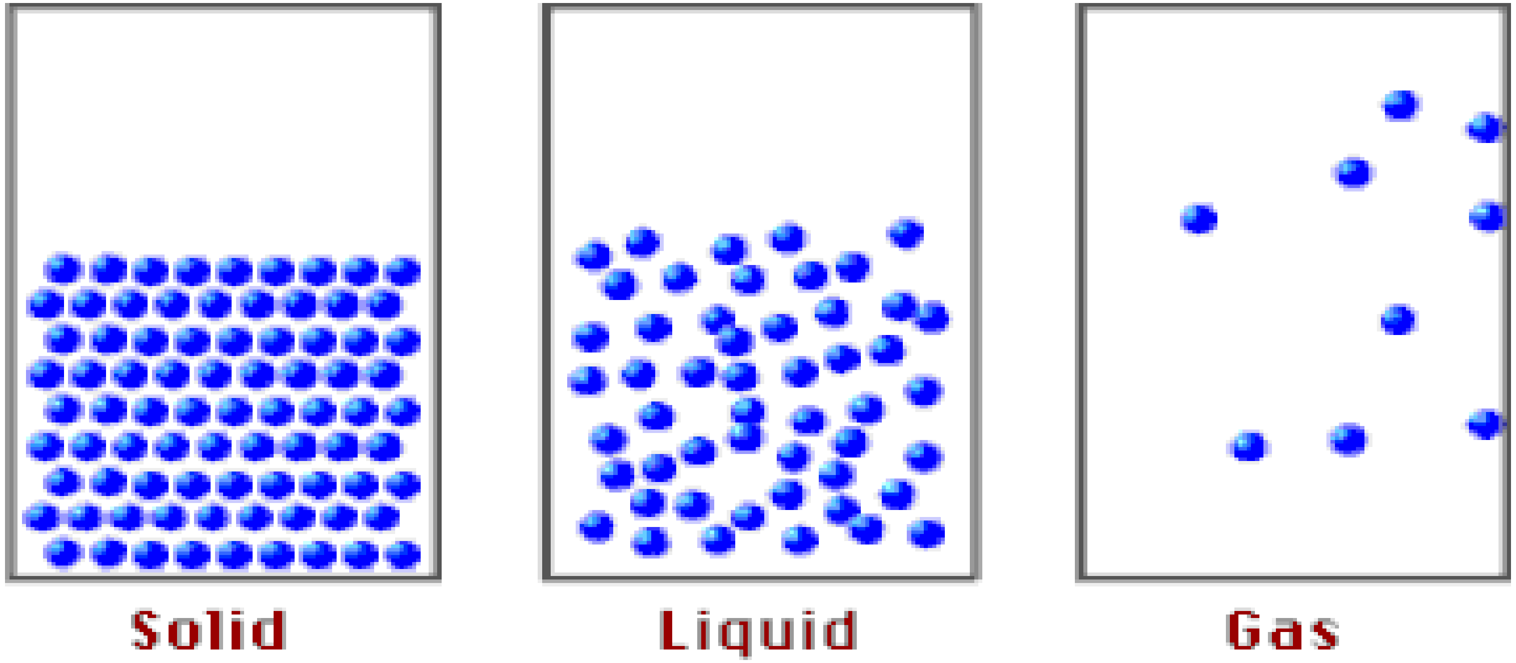
(ii) By lowering temperature

If we cool the gas, the kinetic energy decreases and the particles slow down. As a result, interparticle distances decreases and interparticle forces of attraction increase which pull the gas particles close to form a liquid.



(iii) By combination of both pressure and lowering temperature

Gas can be liquified either by increasing the pressure or by lowering the temperature. However, in most of cases, a combination of both these factors is used to liquefy the gases. If the pressure on the liquified gas is further increased and the temperature further lowered, **the liquified gas may change into the solid state.**



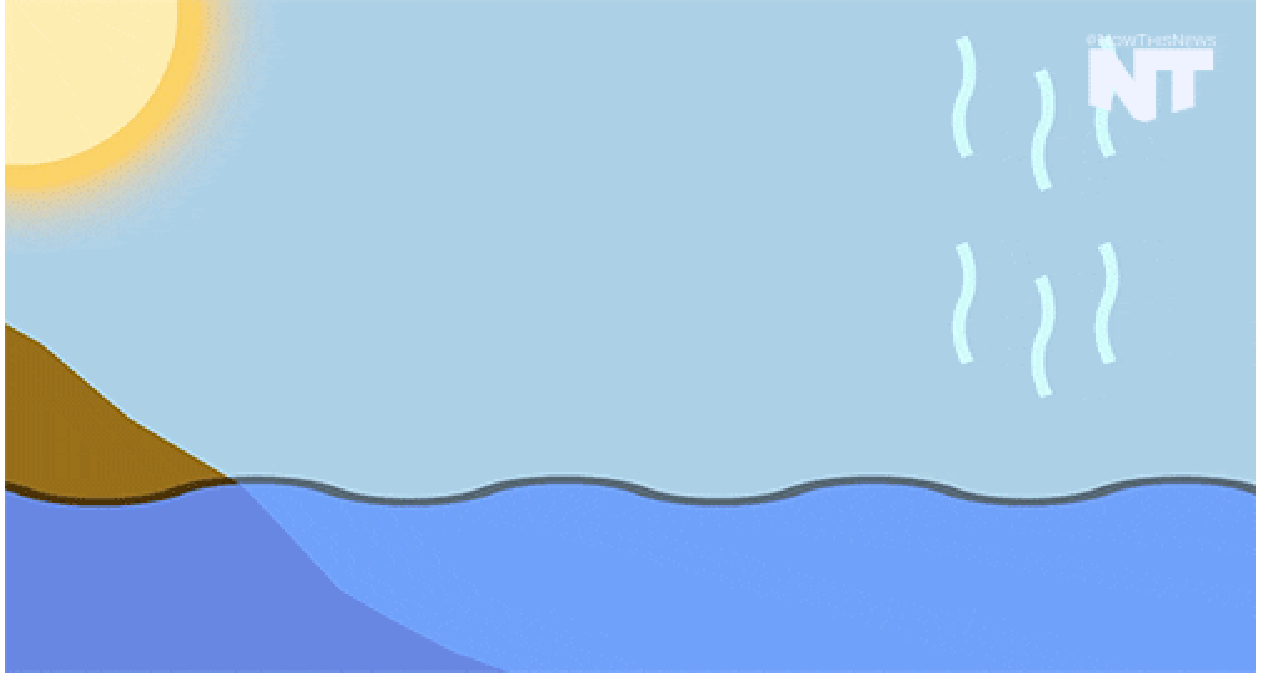
Three conditions of temperature and pressure which decide the state of matter:

- If the melting point of a substance is above the room temperature at the atmospheric pressure, it is called **solid.**
- If the boiling point of a substance is above room temperature under atmospheric pressure, it is called **liquid.**
- If the boiling point of the substance is below the room temperature at the atmospheric pressure, it is called **gas.**

EVAPORATION

"The process of a liquid changing into vapour (or gas) even below its boiling point is called evaporation."

Whatever be the temperature at which evaporation takes place, the latent heat of vaporization must be supplied whenever a liquid changes into Vapour(or gas).



Some particles in a liquid always have more kinetic energy than the others. So, even when a liquid absorbs heat, below its boiling point, some of its particles have enough energy to break the forces of attraction between the particles and escape from the surface of the liquid in the form of vapour (or gas). Thus, the fast moving particles(or molecules) of a liquid are constantly escaping from the liquid to form vapour (or gas).

For example,

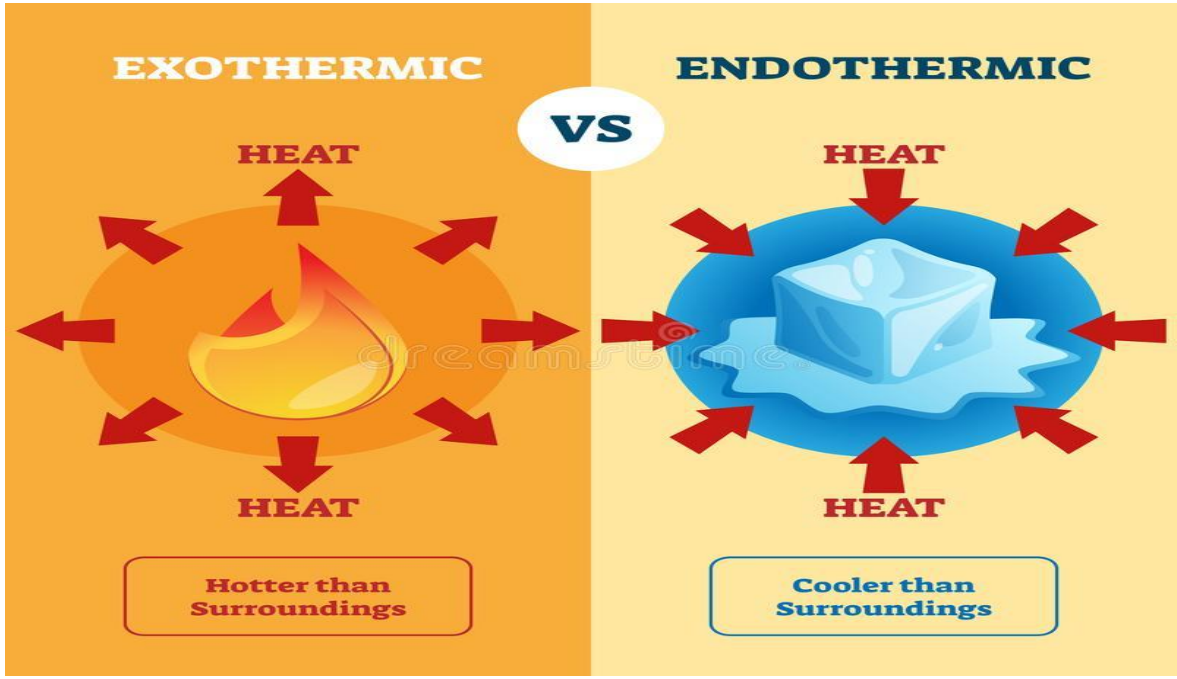
(i) Water in ponds changes from liquid to vapour without reaching the boiling point.

(ii) Water when left uncovered slowly changes into vapour.

(iii) When we put wet clothes for drying, the water from the clothes goes to the atmosphere.

Note:

Evaporation is an endothermic process while **condensation** is an exothermic process.



EVAPORATION V/S BOILING

S.NO	Evaporation	Boiling
1.	**Evaporation process takes place spontaneously at all temperatures.**	**Boiling take place only at definite temperature(boiling point) at the vapour pressure of the liquid is equal to atmospheric pressure.**
2.	**Evaporation takes place only at the surface of liquid.** **Evaporation is a surface phenomenon.**	**Boiling take place even below the surface of the liquid in the form of bubbles.** **Boiling is a bulk phenomenon.**
3.	**It always cause cooling.**	**No cooling.**

FACTORS AFFECTING RATE OF EVAPORATION

- Nature of liquid
- Surface area of liquid
- Wind speed
- Humidity
- Temperature

(i) Nature of liquid

Different liquids have different rates of evaporation. A liquid having weaker interparticle attractive forces evaporates at faster rate because less energy is required to overcome the attractive forces.

For example, Acetone evaporates faster than water.

(ii) Surface area of the liquid

The evaporation depends upon the surface area. If the surface area is increased, the rate of evaporation increases because the high energy particles from liquid can go into gas phase only through surface.

For example,

(a) The rate of evaporation increases when we put kerosene or petrol in an open china dish than in a test tube.
(b) Clothes dry faster when they are well spread because the surface area for evaporation increases.

(iii) Temperature

Rate of evaporation increases with increase in temperature. This is because with the increase in temperature more number of particles get enough kinetic energy to go into the vapour state(or gaseous state)

For example, Clothes dry faster in summers than in winters.

(iv) Humidity in the air

The air around us contains water vapour or moisture. The amount of water present in the air is referred to as humidity. The air cannot hold more than a definite amount of water vapour at a given temperature. If the humidity is more, the rate of vaporization decreases. The rate of evaporation is more if the air is dry.

For example,

Clothes do not dry easily during rainy season because the rate of evaporation is less due to high moisture content(humidity) in the air.

(v) Wind speed

The rate of evaporation also increases with increase in speed of the wind. This is because with increase in speed of wind, the particles of water vapour move away with wind in resulting decrease in the amount of vapour in the atmosphere.

For example,

(a) Clothes dry faster on a windy day.
(b) In a desert cooler an exhaust fan sucks the moist air from the cooler chamber which results in greater rate of evaporation of water and hence greater cooling.

EXAMPLES OF EVAPORATION

1. **We should wear cotton clothes in hot summer days to keep cool and comfortable.**
2. **We see water droplets on the outer surface of a glass containing ice-cold water.**
3. **Water keeps cool in the earthen pot(matki) during summer.**
4. **Rapid cooling of hot tea.**
5. **A wet handkerchief is placed on the forehead of a person suffering from high fever.**
6. **We often sprinkle water on the road in summer.**

Why evaporation causes cooling?

Explanation

During evaporation, cooling is always caused. This is because evaporation is a phenomenon in which only the high energy particles leave the liquid surface. As a result, the particles having low energy are left behind.

Therefore, the average molecular energy of the remaining particles left in the liquid state is lowered. As a result, there is decrease in temperature on the part of the liquid that is left. Thus, evaporation causes cooling.

For example

When we pour some acetone(nail polish remover) on our palm we feel cold. This is because the particles gain energy from our palm or surroundings and leave the palm feeling cool.

Gas V/S Vapour

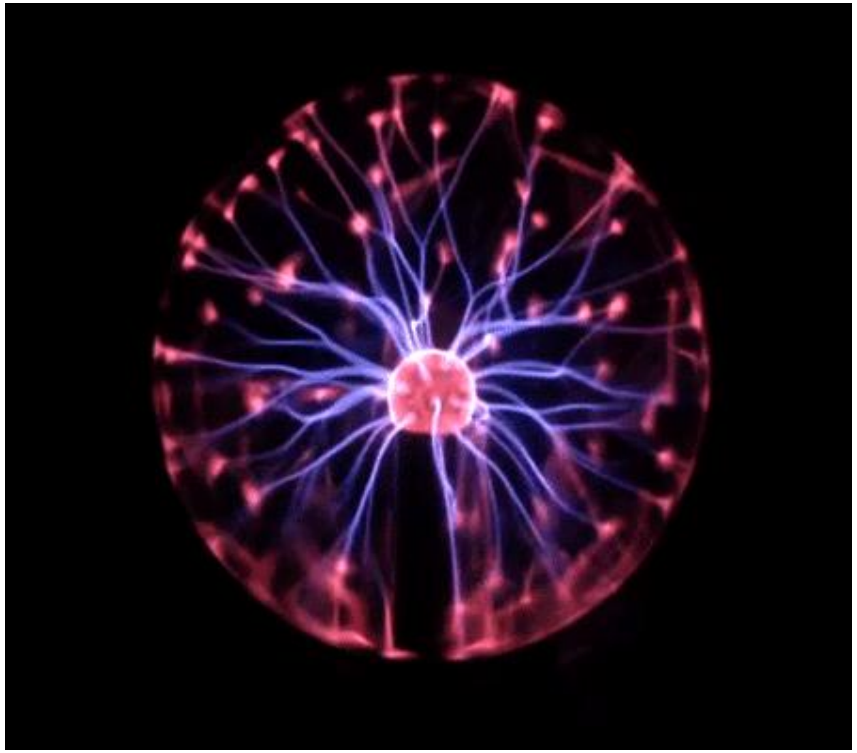
S.NO	Gas	Vapour
1.	**A gas refers to a substance that has a single defined thermodynamic state at room temperature.**	**A Vapour refers to a substance that is a mixture of two phases at room temperature, namely gaseous and liquid phase.**
2.	**At the temperature of interest, gases do not condense.**	**At the temperature of interest, vapours can be in equilibrium with their liquid state.**

ARE THERE ANY OTHER

STATES OF MATTER ??????

PLASMA

Definition: Plasma is a fourth phase of matter, apart from the traditional solids, liquids, and gases. It is a most common state of matter made from a gas that has lost its electrons from heat. Plasma was first identified as "radiant matter" by Sir William Crookes in 1879.



Composition:

- Plasma may be formed by heating and ionizing a gas. It is a collection of charged particles that respond strongly and collective to electromagnetic fields, taking the form of gas like clouds or ion beams.

- Plasma is distinct from a gas because it possesses unique properties.

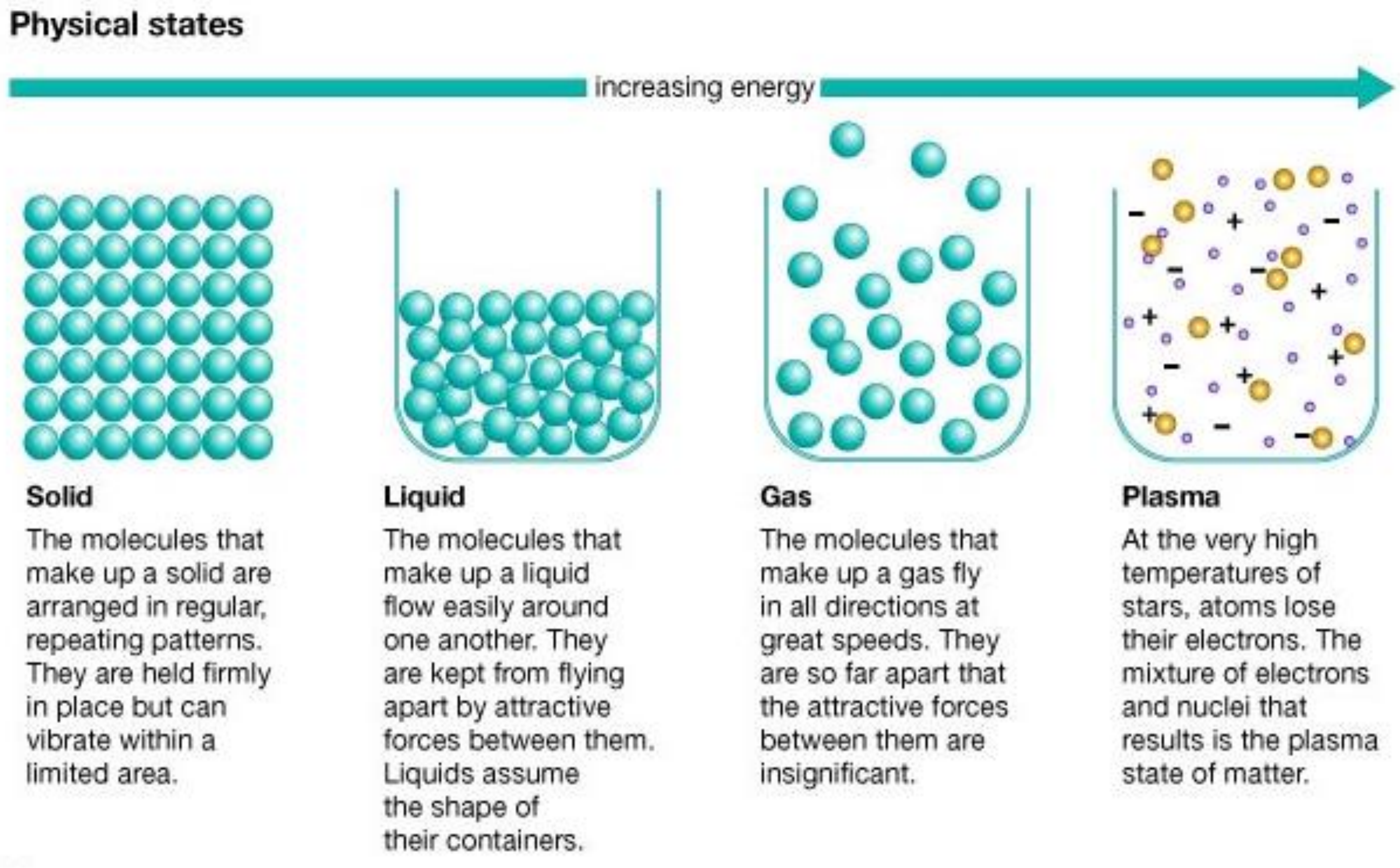
- Plasma has neither a definite volume nor a definite shape.

- Free electrical charges(not bound to atoms or ions) cause plasma to be electrically conductive.

For example, Flame, interstellar nebulae, lightning stars, and even the empty vastness of space are all examples of the plasma state of matter. You can find plasma inside fluorescent lights and neon signs.

Since the particles in plasma are electrically charged(generally by being stripped of electrons), it is frequently described as an "ionized gas".

Increasing order of energy in states of matter



Solid

The molecules that make up a solid are arranged in regular, repeating patterns. They are held firmly in place but can vibrate within a limited area.

Liquid

The molecules that make up a liquid flow easily around one another. They are kept from flying apart by attractive forces between them. Liquids assume the shape of their containers.

Gas

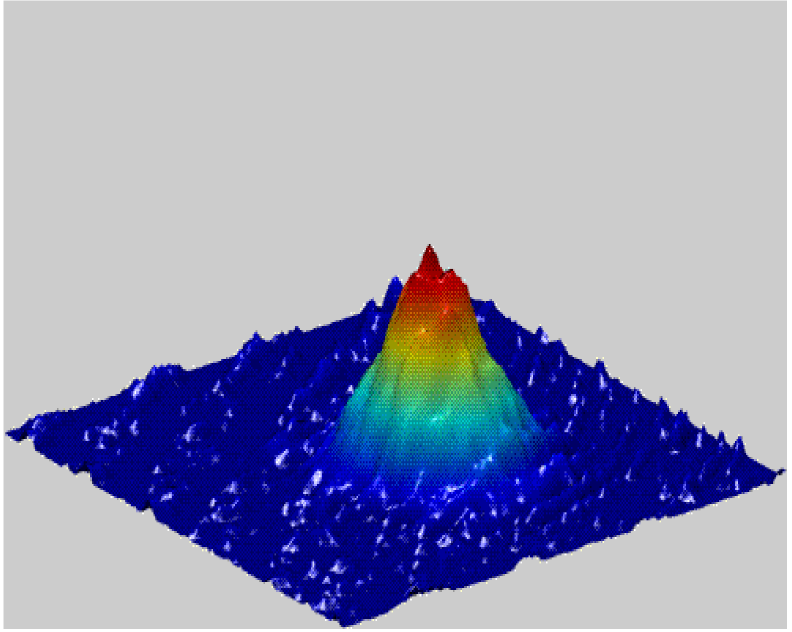
The molecules that make up a gas fly in all directions at great speeds. They are so far apart that the attractive forces between them are insignificant.

Plasma

At the very high temperatures of stars, atoms lose their electrons. The mixture of electrons and nuclei that results is the plasma state of matter.

Bose-Einstein condensate-
BEC(5th state of matter)

A Bose-Einstein condensate is a **gaseous superfluid phase** formed by **atoms** cooled to **temperature** very near to **absolute zero.** The first such condensate was produced by **Eric Cornell**, **Ketterle** and **Carl Wieman** in **1995**, using a gas of **rubidium** atoms cooled at 170 nanokelvins (nK). Two other scientists, **Satyendra Bose** and **Albert Einstein**, had predicted it in the 1920. They didn't have the equipment and facilities to make it happen in the 205, If plasmas are super hot and super excited atoms, the atoms in a Bose Einstein condensate(BEC) are total opposites. They are super-unexcited and super-cold atoms.



The BBC forms at super low temperatures. At zero Kelvin all molecular motion stops.

When you get to a temperature near absolute zero, atoms begin to clump. The result of this clumping is the BEC. A group of atoms takes up the same place, creating a **"super atom".** There are no longer thousands of separate atoms. They all take on the same qualities and for our purposes become one blob.